Cule-H02656-3-257381

FOR FAVOUR OF EXCHANGE

AGRA UNIVERSITY JOURNAL OF RESEARCH

Vol. III, Part I. *SCIENCE* **January 1954**

Abbr. *Agra Univ. J. Res. (Sci.)*

JBLISHED BY

THE REGISTRAR, AGRA UNIVERSITY
AGRA 1954
Annual subscription : Inland Rs. 15/- Foreign Rs. 20/-

CALCUTTA
CENTRAL LIBRARY

CHANCELLOR

Shri K. M. Munshi, Governor, Uttar Pradesh State

VICE-CHANCELLOR

Lt.-Col. C. V. Mahajan, M. A. (Oxon.), M. L. A.

REGISTRAR

Dr. L. P. Mathur, D. Sc.

BOARD OF EDITORS

Dr. M. S. Mani, M. A., D. Sc., F. Z. S. I., F. R. E. S., F. L. S. (*Chief Editor*)
Dr. S. S. Deshpande, M. Sc., Ph. D. (Lond.)
Dr. P. N. Wahi, M. D., M. R. C. P.
(Miss) M. E. Gibbs, M. A. (Oxon.)
Dr. L. P. Mathur, D. Sc. (*Ex-officio*)

CLERK IN-CHARGE, JOURNAL

Shri Dal Chand Sharma, B. A., Visharad.

3

Agra University
Journal of Research

Vol. III, Part I **Science** **January 1954**

PARACHOR AND HYDROGEN BONDING

By R. P. Shukla and W. B. Bhagwat, *Chemistry Department, Holkar College, Indore.*

It is now well established that the hydrogen atom, already joined in a stable manner by a pair of electrons to another atom, is capable, under certain conditions, of accepting another pair of electrons (9). According to Sidgwick (13) this results in an increase of one unit in covalency. Pauling (10) has shown that this type of combination is actually electrostatic in nature and the strength of the union depends upon the nature of the uniting atoms. The existence of hydrogen bond has been established by various methods. Thus, the determination of inter-atomic distances by x-ray diffraction method in case of sodium hydrogen carbonate (3) and potassium hydrogen phosphate (6) shows the existence of O...H...O bond in these compounds. Electron diffraction measurements can also be used for the detection of hydrogen bond, but its application is limited, since the method is usually applied to vapours at low pressure.

In addition to above direct methods of detecting the presence of hydrogen bond, there are several indirect methods, by which the presence of hydrogen bond in a molecule can be recognised. The study of infra-red absorption spectra has established the existence of N-H-O bond in proteins and O-H-O bond in cellulose. Volatility has been used to demonstrate the presence of hydrogen bond in purrazoles (7). Solubilities in donor solvents are also indicative of the existence of hydrogen bond (14) . The depression in melting point caused, in presence of liquid water is a useful guide to chelate hydrogen bond struture (15). Molecular association by hydrogen bonding has been studied by determining the molecular weight (4).

Sidgwick (14) has confused the hydrogen bonding with increase in covalency and applied parachor defects to indicate the increase in covalency by one unit. We (2) have shown, that parachor method can be used to detect the presence of hydrogen bond and also to distinguish between resonance and hydrogen bonding if both are possible. We have shown that the value of parachor defect need not be constant, since the strength of the bond varies, depending on the nature of the combining atoms. We have extended this work in this paper and the experimental procedure is the same as before (2). Our results are summarised in the following Tables. They symbols, x, t, d, r, Pm and Px have the usual significance.

TABLE I

Ethylene Chlorhydrine in Benzene

Temp. ^{O}C	x	d	r	P_m	P_x
29.3	1.0000	1.2812	35.873	162.51	162.51
30.6	0.53370	1.0181	30.690	132.78	162.01
30.1	0.51203	1.0112	30.451	133.59	161.81
30.0	0.45300	0.99517	34.088	191.59	161.79
28.5	0.37687	0.98018	52.468	189.648	161.85
29.6	0.57346	1.0314	31.646	181.003	162.34
29.2	0.59498	1.0385	31.146	180.17	162.00

TABLE II

O-Nitrotoluene in Benzene

Temp. ^{O}C	x	d	r	P_m	P_x
30.8	0.40785	1.0042	33.474	243.57	297.41
31.9	0.54148	1.0454	34.850	258.39	297.39
33.6	0.39921	0.99701	32.978	242.96	297.84
31.9	0.47863	1.0254	34.538	250.07	297.52
31.6	0.48192	1.0262	34.522	250.35	297.46

TABLE III

Acetamide in Water

x(Acetamide)	T °C	d	r	P_m	P_x
0.1792	20.0	1.049	54.12	65.21	128.0
0.20436	20.1	1.0511	53.68	67.939	128.92
0.2280	20.0	1.0531	52.48	69.92	129.91
0.25592	20.2	1.0561	51.382	72.293	130.51
0.2818	20.0	1.0592	50.740	74.47	131.2
0.17845	29.9	1.0223	49.911	65.788	127.95
0.12978	29.9	1.0160	52.420	61.746	125.13

TABLE IV

Acetamide in MeOH

x(Acetamide)	T °C	d	r	P_m	P_x
0.15449	25.6	0.84937	27.874	97.911	149.90
0.18197	27.2	0.85941	28.635	99.359	148.13
0.16846	27.3	0.85439	28.455	98.786	149.51
0.19279	27.2	0.86874	29.951	100.190	148.81
0.14781	27.2	0.84606	27.466	97.388	148.51
0.13243	27.2	0.84016	27.535	96.981	148.74
0.11646	27.2	0.83407	26.387	95.523	148.81
0.18985	27.3	0.81996	25.239	93.281	148.81

TABLE V

Urea in MeOH

x(Urea)	T °C	d	r	P_m	P_x
0.10595	28.9	0.85073	26.804	93.911	139.81
0.10081	27.8	0.85290	26.472	93.923	141.92
0.10002	26.9	0.85398	25.598	93.742	140.81
0.092683	26.9	0.85507	28.282	93.238	140.01

TABLE VI

Urea in Water

x(Urea)	T °C	d	r	P_m	P_x
0.09861	26.0	1.0701	72.04	60.09	130.9
0.12532	26.0	1.0871	71.69	62.15	130.6
0.11151	26.5	1.0786	70.227	60.855	129.81
0.14931	26.0	1.1012	71.391	64.06	130.8
0.18582	28.6	1.0993	75.754	67.760	126.43
0.12154	28.6	1.0832	70.512	61.785	130.42

TABLE VII

Benzamide in MeOH

x(Benzamide)	T °C	d	r	P_m	P_x
0.059607	27.7	0.84837	26.767	99.911	279.51
0.060144	27.2	0.84887	26.613	99.877	279.82
0.061235	27.7	0.84937	26.461	100.039	280.88
0.060048	27.7	0.84839	27.523	100.077	279.14
0.052918	27.7	0.84065	26.164	98.662	279.91
0.044999	27.7	0.83292	25.598	97.107	278.29

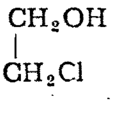
TABLE VIII

Ethylacetoacetate in Benzene

x(Ester)	T °C	d	r	P_m	P_x
0.2907	23.0	0.2976	26.30	231.5	298.0
0.1973	20.7	0.9139	28.32	222.8	298.8
0.1791	26.0	0.9140	29.43	222.7	299.2
Temp.	'd'	'r'	'p'		
21.5	1.023	25.12	302.0		
22.5	1.028	24.40	301.2		

DISCUSSION

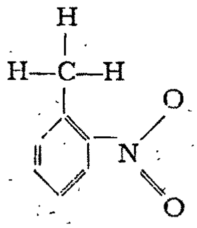
Pauling (10) has shown the evidence of Cl-H—O bond in orthochlorophenol. Similar evidence has been adduced for weak Cl-H—O bond in ethylene chlorohydrine. Our parachor results (Table 1) give an approximate value of 162 for ethylene chlorohydrine in Benzene. The calculated value for the structure,



$$\begin{array}{l} CH_2OH \\ | \\ CH_2Cl \end{array}$$

is 171.9. The parachor defect observed in this case therefore confirms the existence of hydrogen bond in this compound.

The participation of OH—group is chelated hydrogen bond formation had frequently been postulated to account for anomalies in certain other di-substituted derivatives of benzene. Thus superior volatility of orthonitrotoluene as compared to its meta and para isomers has been attributed to hydrogen bonding. The observed parachor value (Table 2) for orthonitrotoluene is 297.4, while the calculated one for the structure,



is 311.8. The observed parachor defect therefore supports the existence of hydrogen bond.

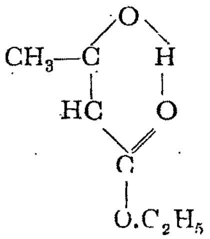
Various possible structures have been suggested for amides. Thus L. Pauling (10) has suggested a resonating structure, while, W. W. Bates and M. E. Hobbs (1), from dipole measurements have shown that there is no reason to suppose the existence of a resonance hybrid. Our results (Table 3 to 7) in methyl alcohol for acetamide, benzamide and urea are 149; 279 and 141 respectively, while the calculated values for the simple ketonic formulae are 150.8, 279.1 and 141.9 respectively. The value for acetamide in fused state is 148.8. The agreement between the experimental and calculated results does not warrant the presence of highly polarised resonance structure, since this should result in lowering of parachor according to our parachor theory of resonance. It is obvious that there appears to be no hydrogen bonding which requires an appreciable value for the parachor defect.

In water, however, there is an appreciable lowering. This was also observed by Ray (11) and S. O. Shukla and Bhagwat (12). This cannot be due to hydrogen bonding, since this is not observed for these compounds in methyl alcohol. We suggest that it is due to ionisation. We have shown that ionisation causes lowering in parachor. Our view is supported by the observation of Wheland according to whom amides ionise in water and various resonance structures of ions are possible.

Ethyl acetoacetate has been represented by the formulae $CH_3COCH_2COOC_2H_5$ and undoubtedly its behaviour with sodium sulphide, hydrochloric acid and hydroxy lamine supports this ketonic structure. However, its behaviour with ammonia and amines and phosphorous pentachloride, etc. indicates that the structure may be $CH_3COH{=}CH_2COOC_2H_5$. Bruhl employed the molecular refraction for the investigation of this problem. The observed value of molar refraction is 31.98 and the values calculated for ketonic and enolic formulae are 31.53 and 32.55 respectively. The conclusion drawn is that at ordinary temperature ketonic form mainly predominates. Mayer and Wilson, by using bromine method of titration, have shown that at ordinary temperatures ester contains only 7% of the enol form which decreases with rise of temperature and increases with different solvents in the order, water, alcohol, acetone, ethyl acetate, benzene, ether, hexane. Thus ethyl acetoacetate exists as an equilibrium mixture of the keto-enolic form.

$$CH_3COCH_2COOC_2H_5 \rightleftarrows CH_3COH \quad CHCOOC_2H_5$$

Sidgwick (14) has shown that for a number of keto-esters, including ethyl acetoacetate the solubility of the enolic form in hydroxyl solvents is relatively less than in benzene or hexane. This implies that the enolic form cannot contain hydroxyl group, since hydroxylic compounds are relatively soluble in water and in alcohol, but only slightly soluble in hydrocarbons. Further, Brown found that the infra-red spectra of ethyl acetoacetate and similar esters do not show the characteristic bands which are always associated with the presence of an ordinary OH group. It seems, therefore, that in agreement with the suggestion made that hydrogen becomes co-ordinated ethyl aceto-acetate (enol) may be existing as



If hydrogen really increases its valency to two then it has a group of four electrons and this is contrary of the postulate of Pauli's principle. However, it is possible that a hydrogen bond is formed which is electrostatic in nature. Sugden suggested that each of the two hydrogen valencies is a singlet so that the group of two is not exceeded. The attachment appears, however, to be too strong to be accounted for by a single electron bond.

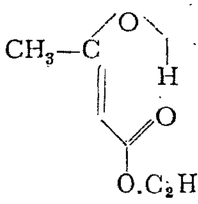
The parachor values of the various forms will be
Keto. 306.2 Enol—306.2
Ring Covalent—310.7 Ring Singlet—289.7
The parachor of ethyl acetoacetate has been determined by us in pure state. The results are as follows:—

Temp	'd'	'r'	'P'
21·5	1·023	25·12	302·0
22·5	1·028	24·40	301·2

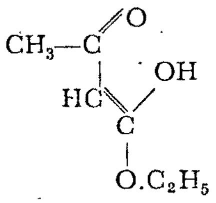
The parachor has also been determined in benzene and the detailed results are given in the experimental part.

Landolt and Bornstein (8) got the value 302 for ethyl acetoacetate.

It will be clear, therefore, that there is no hydrogen bond formation as there is no appreciable lowering in parachor. It seems that the open chain structure is more possible. However, the work of Sidgwick (13) on the solubility and of Brown on infrared spectrum show a complete absence of or suppression of OH group in the enol form of ethyl acetoacetate. We explain the behaviour of ethyl acetoacetate by the resonance. Thus there is a resonance between the structures.



and



It will be clear, therefore, that the determination of parachor values is very useful in deciding between hydrogen-bond and resonance when both alternatives are possible.

REFERENCES

1. BATES and HOBBS. 1951. *J. Amer. chem. Soc.*, **13** : 2154.
2. BHAGWAT and R. P. SHUKLA. 1952. Agra Univ. *J. Res.* (*Sci.*) **1** : 169.
3. BUSNELL A. M. and W. H. RODEBUSH. 1940. *J. Phys. Chem.* **44** : 1126.
4. BECKMAN E. and K. VON. AUERS. 1937. *Berl Chem.* **70** : 966.
5. CHAPLIN H. O. and L. HUNTER. (1938). *J. Chem. Soc.*, p. 1034.
6. ELLIS J. W. and J. BATH. 1940. *J. Amer. chem. Soc.*, **62** : 2859.
7. HAYES S. T. and L. HUNTER. 1941. *J. chem. Soc.*, p. 10.
8. LANDOLT and BORNSTEIN. 1931. *Zewil Erganzungland* **188** : 172.
9. MOORE and WINMILL. 1912. *J. chem. Soc.*, **101** : 1675.
10. PAULING L. 1945. Nature of Chemical Bond, p. 127.
11. RAY. 1935. *J. Indian chem. Soc.* 12 : 406.
12. S. O. SHUKLA and W. V. BHAGWAT. 1944. *J. Indian chem. Soc.*, **21** : 179.
13. SIDGWICK N. V. 1925. *J. chem. Soc.*, **29** : 909, 2739.
14. SIDGWICK N. V. 1923. *J. chem. Soc.* **123** : 2111.

ION EXCHANGE CHROMATOGRAPHY

USE OF SULFONATED COAL FOR THE EFFECTIVE SEPARATION OF SILVER AND COPPER IN A MIXTURE.

By R. P. SHUKLA and R. P. BHATNAGAR, *Department of Chemistry, Holkar College, Indore.*

Separation of cations by cation exchange chromatography is rapidly expanding (1). Tompkins and Mayer (4) have worked out the details of the separation of rare earth compounds by ion exchange resin. Thus, according to Tompkins, Khym and Cohn (5) a mixture of fission produced radio isotopes including some rare earths can be resolved by using amberlite IR-I columns. Taylor and Urey (3) used naturally occurring zeolites for the fractionation of isotopes. The experiments were made with lithium, potassium or ammonium, the isotopes of which behave differently enough on the zeolite to permit a partial fractionation. Thus we see that this long neglected ion exchange process is rapidly developing as an important unit process. We have used sulphonated coal (permutit, S) as the resin in the separation of silver from a mixture of copper and silver.

Experimental.—Indian coal has first been sulphonated in the National Chemical Laboratories, India by Bafna, Pai and Shah (2). They used various dehydrating agents and tried to increase the exchange capacity of the resin. We took the mineral coal from the railway department and pulverised it. The gradation of the particles was done by seiving. The coal particles which could pass through 50 mesh seive but could not pass through 100 mesh seive were taken. 500 gms. of this graded coal was mixed with 200 ml. of oleum sulphuric acid and allowed to sulphonate in cold for three hours. The mixture was cooled from time to time as heat was produced during sulphonation, if sulphonation is allowed to go on at high temperature some of the organic matter (carbon) reacts with the sulphuric acid and a valuable quantity of $H_2 SO_4$ is lost. Afterwards the sulphonated coal was repeatedly washed with distilled water till free from acid, which was tested by testing the washings with methyl orange. It was then dried in an oven at 100° C till the water content was ca. 35% by wt.

The phenomenon of ion exchange may be studied by employing either the column or the batch technique. We used the column method. The resin was packed in a vertical column made with the help of a 50 c.c. burette and the material to be treated was run through it. When a certain predetermined concentration of the material being removed from the influent began to appear in the effluent, the resin was regenerated with 6% HNO_3. A small 'plug' or fold of glass-wool was inserted in the burette above the stopper. Then, enough fine sand (20 to 30 mesh size) was charged to the column so that a bed two or three inches high was formed above the glass wool. This makes the resin to stay in position and does not permit it to clog the mouth of the burette.

After having set the apparatus we used it for the isolation of Ag from a mixture of Cu and Ag. First we took pure solutions of copper and silver nitrates and examined the rate of absorption. Afterwards mixtures were used. Following tables give our results :-

Volume of Resin—30 6. cc 6.
Speed of flow of the solutions—one drop per five seconds.

TABLE 1

Exchange of Copper sulphate

No.	Vol. of Solu. used each time	Strength of $CuSO_4$Solu.	Vol. of hypo. (N/10)sol. used eluted solu.	Vol. of hypo. required for initial solu.
1	10 c. c.	N/10	3.7 c. c.	9. 9 c. c.
2	,, ,,	,,	3.7 c. c.	9. 9 c. c.
3	,, ,,	N/20	0.9 c. c.	5.0 c. c.
4	,, ,,	N/20	0.9 c. c.	5.0 c. c.
5	,, ,,	N/40	0.7 c. c.	2.5 c. c.
6	,, ,,	N/40	0.7 c. c.	2.5 c. c.

Table No. 2

Exchange of $AgNO_3$ *Solution*

No.	Vol. ef Solu. used each time	Strength of $AgNO_3$ Solu.	Vol. of KCNS (N/10) Solu. for eluted solu.	Vol. of KCNS Solu. required for initial solution.
1	10 c. c.	N/10	0.0 c.c.	10.0 c.c.
2	„ „	„	„	„ „
3	„ „	N/2	0.0 c.c.	49.0 c.c.
4	„ „	N/2	0.0 c.c.	49.0 c.c.
5	„ „	N	14.6 c.c.	100.3 c.c.
6	„ „	N	14.5 c.c.	100.5 c.c.

Table No. 3

Separation of silver from a mixture cf copper and silver.

No.	Vol. of sol. used each time	*Contents of Mixture*		KCNS solu. required for	KCNS solu. (N/10) requ. for exchanged solu.	% of Ag. completely of lated
		% of Cu.	% of Ag.			
1	20 c.c.	50 %	50 %	10 c.c.	5.5 c.c.	55%
2	20 „	66.7 %	33.3 %	„ „	3.2 „	32%
3	20 „	75.0 %	25.0 %	„ „	2.35 „	23.5%
4	20 „	80.0 %	20.0 %	„ „	1.8 „	18.0%
5	20 „	90.0 %	10.0 %	„ „	0.85 „	8.5%

N. B. Mixture of Ag. Cu. were prepared by mixing different volumes of $AgNO_3$ solution and $Cu(NO_3)_2 . 3H_2O$ (N/10) solution.

Discussion.—Thus it will be seen from the tables 1 and 2 that the resin has a preference for Ag ions than Cu ions, because even a N/2 solution of $AgNo_3$ when taken (10 c. c.) is completely absorbed while an equal volume of N/10 solution of $CuSO_4$ was only 50% absorbed. Thus we see that the isolation of Ag from a mixture of Cu and Ag is a practical idea. From the table 3 it will be clear that Ag can be separated from Cu even if it is present to the extent of 50%, while if Ag is only 33% or less, though the isolation can be done the efficiency of the column is only

33%. It was possible for us to crystallise pure $AgNO_3$ from the various mixtures. The idea behind this work is the isolation of Ag from copper bearing Ag ores like polybasite 9 (Ag_2S, Cu_2S), Sb_2S_3 and old coins (6). Further work on the effect of the presence of Sb and other impurities is being continued. It will be seen that polybasite contains 50.3% of Ag and 30% copper by formula weight. Hence the efficiency of the column in the isolation of silver will be 55% and if the cycle of operation is carried out two or three times with the same solution or a bigger column is used all the silver can be isolated.

REFERENCES

1. APPLEZIG. 1946, *Ann. New York, chem. anal*, **18** : 82.
2. BAFNA, PAI and SHAH 1951, *current. Sci.*, **20** : 233.
3. TAYLOR and UREY. 1937, *J. Chem. Soc.*, **5** 597.
4. TOMPKINS and MAYER. *J. Ameriaan chem. Soc.*, **69** 2769
5. TOMPKINS. MAYER and COHN. 1947. *J. American chem. Soc.*, **69** : 2859.
6. WALKER. 1924, A Text-book of Inorganic Chemistry, p. 290.

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

I—INTRODUCTION, DESCRIPTIONS OF GALL MIDGES (ITONIDIDAE = CECIDOMYIIDAE : DIPTERA) and PLANT GALLS FROM THE WESTERN HIMALAYAS.

By M. S. MANI, M. A., D. Sc., F. R. E. S., F. L. S., *Professor of Zoology & Entomology, School of Entomology, St. John's College, Agra.*

INTRODUCTION

In the course of an insect survey of the Himalayas, first begun in the autumn of 1952, extensive collections of extremely interesting torrential insects, numerous gall forming and gallicolous insects and their galls were made. During the summer 1953 two months were spent in the Western Himalayas, especially in the Kangra and Himachal areas. With an advanced base at about 10,000 ft. (Plate I) within a day's march from glacier beds, collections were made upto an altitude of 15,000 ft. A number of remarkable insects occur on the permanent snow fields, within the shadow of the main Himalayan peaks ranging from 15,000 ft. to 20,600 ft. (Baihalijot in the Pangi range). On the Lakka pass (Plate II) (15,000 ft.) in the Dholadhar Range were found, for example, remarkable swarms of living but inactive adults of *Coccinella septempunctata* Linn. strewn on the glacier bed. In the many lakes that occur at about 10,000 ft. (Plate III) and which are fed by glaciers above from the north, there occur a group of Odonata, Ephemerida, Hemiptera and Coleoptera adapted for life in icy-cold water. In the course of a third but short visit in autumn 1953 collections were made at lower altitudes in the Garhwal area.

On basis of distribution of insects we may recognize the following faunal belts : i. Sub-Himalayan belt, ii. foot-hills of the Himalayas, iii. outer Himalayas and iv. main Himalayas. In the north-west the sub-Himalayan belt extends to a part of the foot-hills east of Jhelum River and the whole of the Siwalik Range. Insect life as a whole is perhaps most abundant and varied in this belt. The eastern parts of this belt are comparatively dry and differ faunistically from the west. The second belt comprises the foot-hills ranging in altitudes from about 1000 ft. to 8000 ft. and intersected by numerous water courses, with the hills presenting mostly the southern aspect. This is largely a zone of Orthoptera, Phasmida, giant Corrodentia, cicadas, Tipuloidea, Mycetophiloidea, Bibionoidea, many aquatic and torrential or pond forms of Hemiptera, Diptera and Coleoptera, relatively dark-coloured Lepidoptera, with isolated occurrence of *Bremus*. The third belt comprises the outer Himalayan ranges and include the Kedarnath, Trisul and Badrinath in the Central Himalayas and the Pangi Range in the north-west. While many of the peaks rise above 20,000 ft. the ravines are remarkably low (often 2000 ft.), with the ridges separating them varying between 6000 ft., to 10,000 ft. The Sub-Himalayan faunal element penetrates rather deep up the ravines well within this belt. A certain amount of Palaearctic facies may be recognized in the insect fauna of this belt. The fourth belt with its relatively scanty vegetation even in valleys and within tree-growth limit, possesses an insect fauna clearly adapted for life under arid cold conditions. The variety and abundance of insect life fall off rapidly beyond the tree-growth level, but the permanent snowy wastes are by no means barren. Even within each belt the distribution of insect is closely bound up with the peculiarities of vegetation.

---

*Contribution No. 40 from the School of Entomology; cecidological contribution No. 23.

The first, second and third faunal belts are extremely rich in insect and mite galls. Galls by the midges constitute the largest bulk of the collections. In this paper are described forty-six galls, of which twenty-five are new. Two galls are first records for India. Twenty-one galls are produced by midges, nine by mites and the rest by cynipids and other agencies. While galls on Compositae are practically unknown in the plains and Sub-Himalayan tracts, they become increasingly common in the outer Himalayas. The gall midges from five galls were reared and are described here. The type specimens of the midges are deposited in the collections of the Zoological Survey of India, Indian

Base Camp 10,000 ft. Treund.

Museum, Calcutta and the specimens of the galls are for the present in my collections.

I take this opportunity of expressing my hearty thanks to my Research Associate Mr. Santokh Singh, who accompanied me in the field, collected many specimens and helped in preparing sections of the galls. I am also thankful to my wife and first son for many specimens, and Mr. Tej Bhan Singh Saini, Forest Range Officer, Dharamsala for numerous courtesies.

A. DESCRIPTIONS OF MIDGES

Tribe OLIGOTROPHINI

Rhopalomyia millefolii (H. Low)

1850. *Cecidomyia millefolii*, HERMAN LOW, *Dipt. Beitr.*, **1** : 37
1913. *Rhopalomyia millefolii*, KIEFFER, *Gen. Ins.*, **152** : 44.
1938. *Rhopalomyia millefolii*, RÜBSAAMEN & HEDICKE, Die Cecidomyiden und ihre Cecidien, p. 289, pl. xxiii, fig. 8-11.

I refer to this species one male reared from gall No. 527 on leaf of *Achillea millefolium* Linn. collected in the Reserve Forest, Ala Catchment Area, 8000 ft. Dalhousie, Santokh Singh, 26-vi-1953.

This is the first record of this species from India. The species produces the same gall on *Achillea* spp. in Europe and Egypt.[1]

Rhopalomyia sp.

One female and one pupa from gall No. 505 on terminal bud of *Achillea millefolium* Linn. from the same locality as the foregoing species, but material not satisfactory for a definite specific identification. This is probably identical with *Rhopalomyia millefolii.*

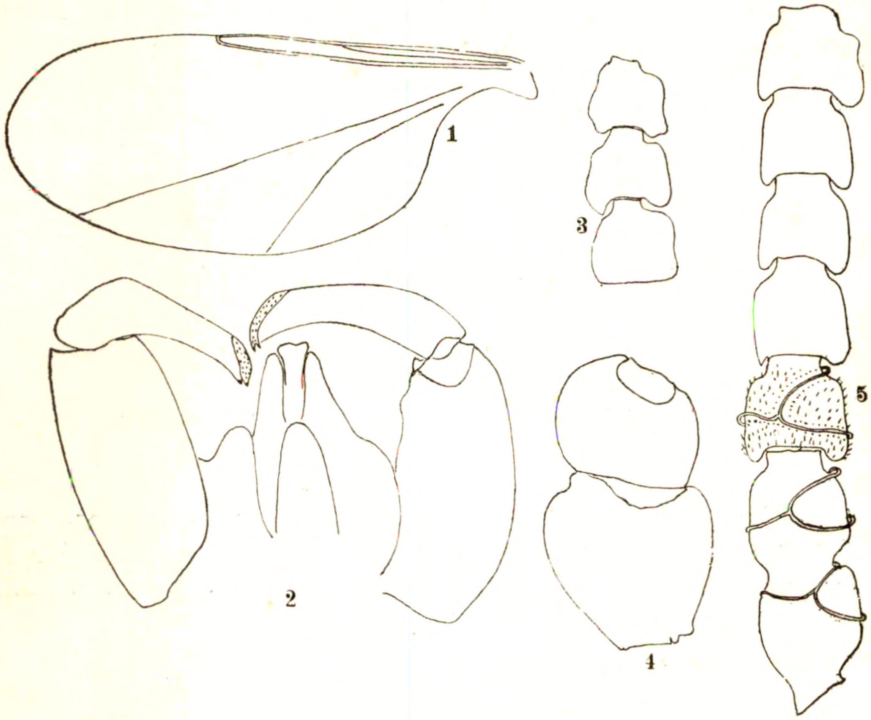
---

[1] HOUARD, C. 1923. Les Zoocecidies des Plantes d'Afrique, d'Asie et d'Oceanie, p. 867, No. 3152, fig. 1804-1805. ROSS, H. & H. HEDICKE. 1927. Die Pflanzengallen Mittel- und Nordeuropas, pp. 75-77, No. 47, 52, 57, 66.

Tribe LASIOPTERINI

Neolasiptera sp.

One male reared from gall No. 479 on leaf of *Machilus odoratissima*, Nees, though not adequate for a definite specific identification, is described below to facilitate future recognition.



Neolasioptera sp. from gall No. 479. 1. wing. 2. genitalia. 3. Terminal antennal segments. 4. Scape and pedicel. 5. Basal antennal segments.

Male.—Length 1 mm. Dark reddish-brown; clothed with black scales. Palpus triarticulate; the basal segment equal to the second segment, each nearly twice as long as thick. Antennae with 24 (?) segments; third and fourth antennal segments fused together; scape and pedicel as fig. 4; fifth antennal segment nearly as long as thick; twentieth antennal segment about three-fourths the fifth segment; twenty-second antennal segment slightly shorter. Mesonotum dark reddish-brown. Scutellum yellowish-brown. Wing as in fig. 1. Fifth tarsal segment nearly half the fourth segment. Claw bifid, equal to empodium. Dorsal plate bifid

Lakka Pass 15,000 ft. on this glacier bed occur *Coccinella 7-punctata*; outside the glacier bed occur many galls, such as on *Gerbera*, *Cyathula*, etc.

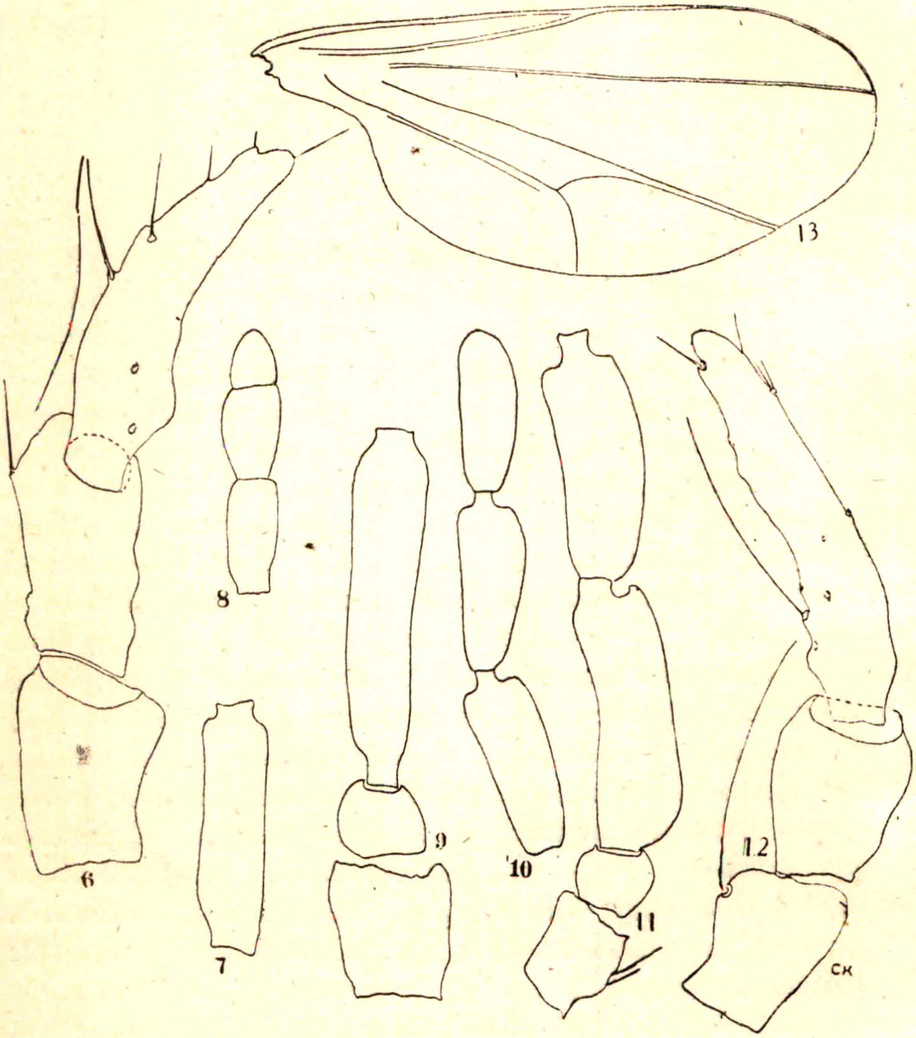
right down to its base; the lobes broadly oval. Ventral plate one and a half times longer than dorsal plate; deeply bilobed; the lobes narrow apically, broadly emarginate basally. Style slightly longer, broadly clavate and truncate. Basal clasp segment slender. Terminal clasp segment as long as basal clasp segment, bidentate.

1 male on slide, emerged from gall No. 479 on leaf of *Machilus odoratissima* Nees, Dharamsala: Kangra District, 4513 ft. Coll. M. S. Mani & Santokh Singh, 2-vi-1953.

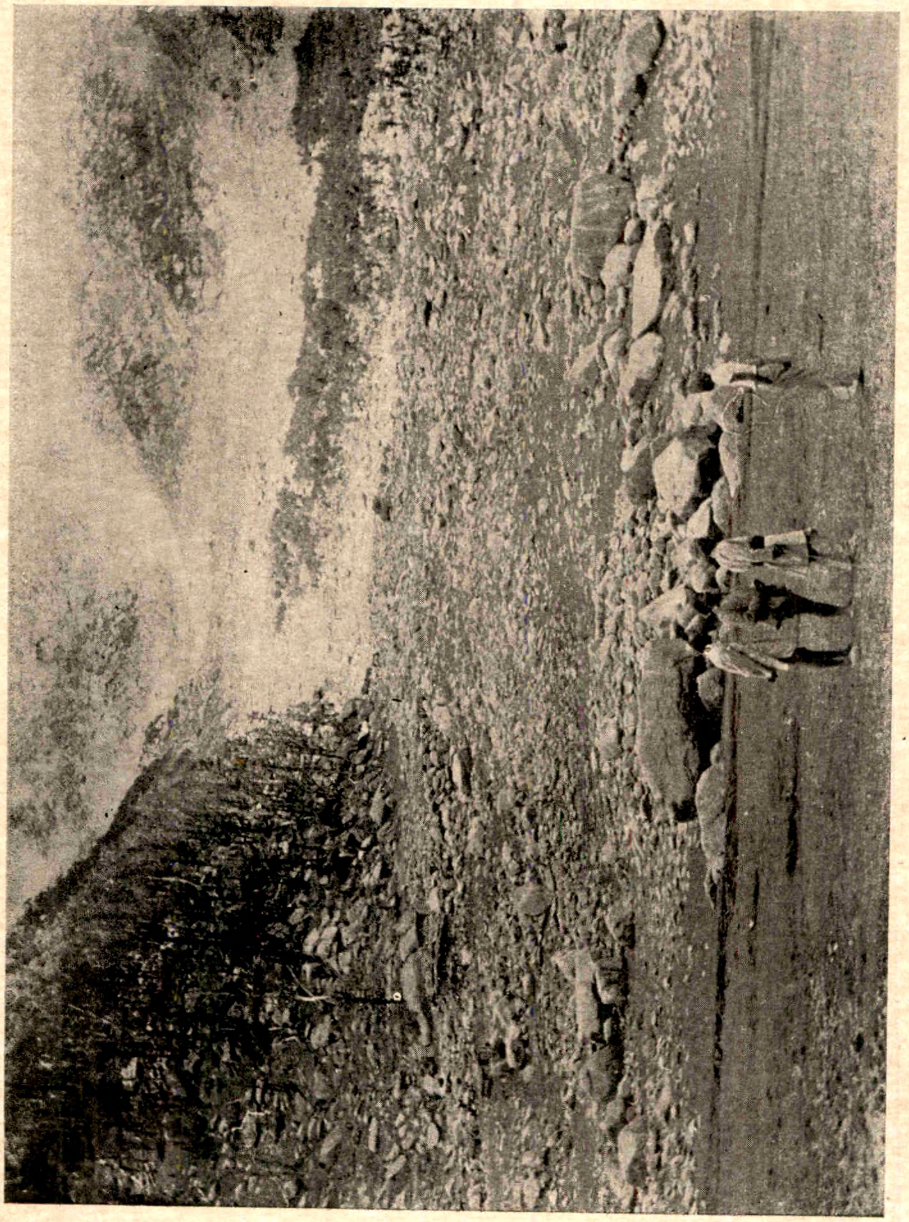
Tribe ASPHONDYLINI

Acroectasis campanulata, sp. nov.

Female.—Length 3 mm. Body yellowish, densely clothed with black scales and setae; short, moderately stout. Head with conspicuous, dense row of long occipital setae; eyes confluent above. Trophi short, inconspicuous. Palpus long, yellow, tri-articulate, with dense long setae; first palpal segment obliquely cordate or pyriform, slightly longer than thick; second palpal segment cylindrical, stout, nearly twice as long as thick, more slender than first segment and nearly one and one-fourth its length; third palpal segment elongate, much longer and more slender than second segment and consisting of a basal stouter one-third and an abruptly more slender apical two-thirds, the thickness of the basal part about seven-tenths of the diameter of the second palpal segment and the thickness of thinner apical part one half the diameter of the second segment; the third segment as a whole is a little less than thrice the length of the second palpal segment; the abrupt reduction in thickness at about basal third presents the appearance of a four-segmented condition. Antennae about half the length of body, yellowish-grey, densely setose, with whorls of long setae in addition to short general pubescence; segments 14, cylindrical sessile, with regular, simple, short circumfila; scape short, stout, thicker apically than basally; pedicel globose, with a diameter about two-thirds the maximum thickness of scape; third antennal segment with a length about five times its diameter; fourth antennal segment about four-fifths the length of third segment and about four times its own thickness; fifth antennal segment somewhat shorter and about two-thirds the length of third segment; segments six to nine each nearly equal to the fifth antennal segment, but each gradually becoming slightly more and more slender; tenth antennal segment distinctly shorter than ninth segment, nearly three times as long as thick; eleventh antennal segment slightly shorter; twelfth antennal segment about three-fourths the length of ninth segment, about half the third segment



Oxasphondylia echinata, sp. nov. 6. Palpus, female, 7. Fourth antennal segment, female, 8. Terminal antennal segments, female, 9. Basal antennal segments, female, 10. Terminal antennal segments, male, 11. Basal antennal segments, male, 12. Palpus, male, 13. wing male.



Mahadev Lake at Kareiri 10,000 ft. Note the Upper limit of tree growth and the glacier.

and somewhat less than the eleventh; thirteenth antennal segment about one-third the third and somewhat less than twice its diameter; fourteenth segment ovate, with a length about one and one-third its diameter and about two-thirds that of the preceding segment. Mesonotum yellowish-brown with some fuscous tinge. Scutellum pale yellowish-brown. Wing black, densely scaled, shape and proportions as in fig. 33. Halteres long. Legs short, yellowish, densely scaled; metatarsus of fore leg about one-seventh the second tarsal segment; third tarsal segment about three times the metatarsus; fourth tarsal segment about two-thirds the third; fifth tarsal segment about two-thirds the fourth. Claw stout, strongly curved, simple. Empodium well developed, distinctly longer than claw. Abdomen short, stout, about two-thirds the length of body, yellowish and densely clothed with black setae. Ovipositor protractile, aciculate, heavily sclerotised, with dorsal pouch at tip of abdomen.

Male.—Length about 2 mm. Body yellowish-brown, densely clothed with black scales and setae. Occiput densely setose. Eyes confluent above. Trophi as in female. Palpus (Fig. 34) elongate, slender, somewhat shorter than in female, triarticulate; first palpal segment short, subglobose; second palpal segment nearly twice as long as first, but more slender, length about one and a half times its own diameter; third palpal segment longest, much more slender, a little more than twice the length of the second palpal segment, abruptly reduced beyond basal third as in female. Antennae a little over half the length of body, yellowish-grey, densely setose, setae in whorls, segments 14, with regular, simple circumfila; scape (Figs. 30-32) short, stout, subquadrate in lateral outline, nearly as long as thick; pedicel oblate-spheroid, shorter, darker and more slender than scape, length about two-thirds the thickness; third antennal segment about four times as long as thick, about three-fourths the thickness of pedicel, its diameter is equal to the length of pedicel; fourth antennal segment somewhat shorter than third, about three and two-thirds as long as thick; segments five, six, seven, eight, nine, ten and eleven subequal and about four-fifths the fourth antennal segment; twelfth antennal segment somewhat shorter than the eleventh and slightly reduced apically; thirteenth antennal segment somewhat shorter than twelfth and more slender, about five-eighths the length of third antennal segment and about two-thirds its thickness; fourteenth antennal segment pyriform, a little more than one-fourth the length of thirteenth segment, its length about one and a half times its own diameter; its thickness about two-thirds that of the thirteenth segment. Mesonotum dark brown with black. Scutellum pale brown. Wing as in fig. 33. Legs short, black, densely scaled and setose. Metatarsus about one-sixth the second tarsal segment; third tarsal segment about half the second; fourth segment about two-thirds the third tarsal segment; fifth tarsal segment about half the third. Claw stout, strongly curved, simple. Empodium well developed, distinctly longer than claw. Abdomen about three-fifths the length of body. Genitalia (Fig. 35-36) small, short, very dark brown, densely setose. Dorsal plate short, broadly emarginate, broadly obtusely incised apically, the lobes broad, short, subtriangular. Ventral plate longer than dorsal plate, deeply bilobed, the lobes long, narrowly triangular. Style heavily sclerotised, brown, nearly as long as basal clasp segment, curved dorsally. Basal clasp segment short, stout, simple. Terminal clasp segment short, stout, obpyriform, abruptly slender basally, nearly as long as the basal clasp segment, apically with two conspicuous, widely separated blunt teeth at either end of a shallow depression.

Holotype one female, *allotype* one male, *paratypes* males and females. Reared from gall No. 500 on branches of *Sabia campanulata* Wall. Kalatop Reserve Forest, 8000 ft. near Dalhousie (Gurdaspur District) : Punjab. M. S. Mani, 18-30. vi. 1953.

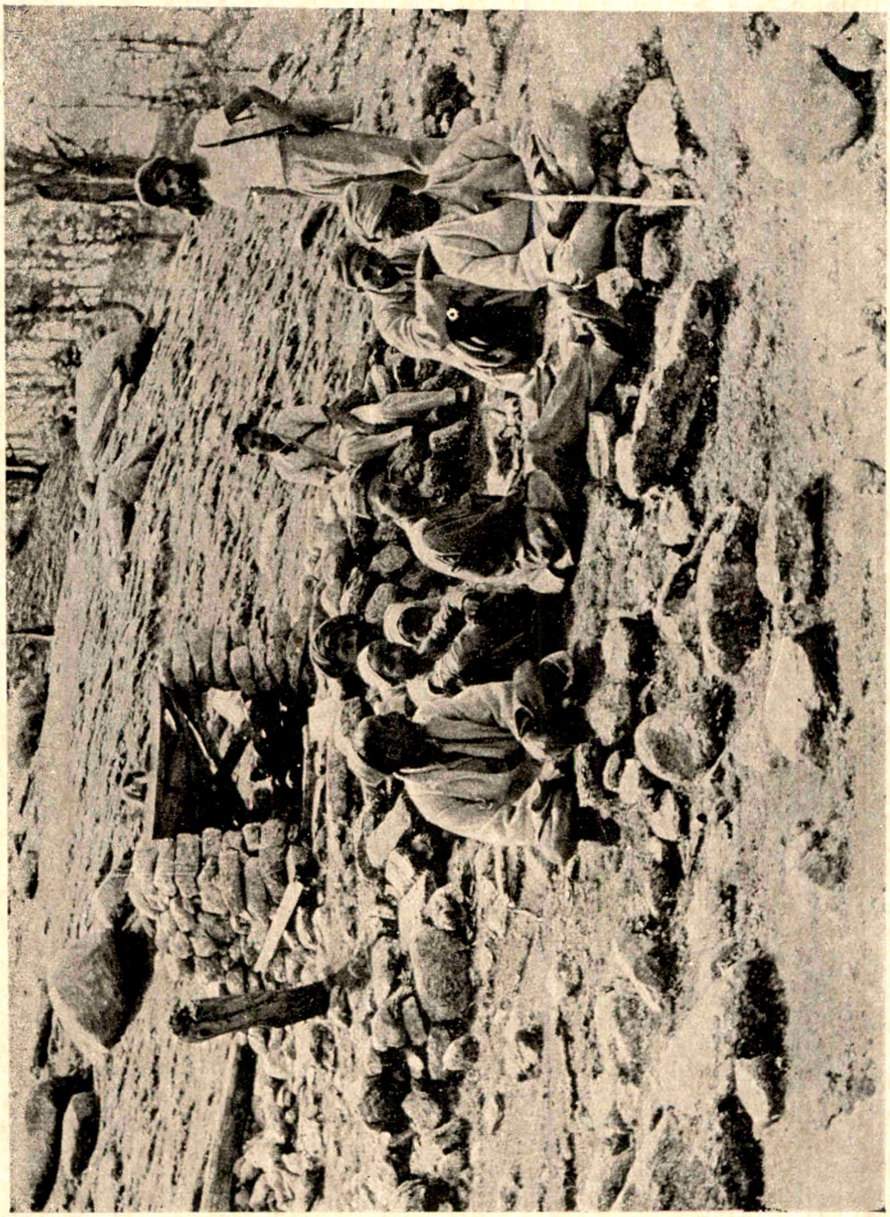
This is the first record of the genus *Acroectasis* Rubsaamen[1] from India.

Oxasphondylia echinata, sp. nov.

Male.—Length 3.0 mm. Black. Palpus (Fig. 12) moderately long, triarticulate; first segment short, stout, obliquely subquadrate, about one and a half times as long as thick; second palpal segment longer, slightly more slender, nearly twice as long as thick and almost as long as the first; third palpal segment much longer and more

---

[1] RUBSAAMEN, E. H. 1910. *Z. wiss. Insektenbiol.*, **6** : 131. KIEFFER, J. J. 1913. *Gen. Ins.*, 152 : 131 Genotppe *A. maura* Rubs. Germany



Camp at 10,000 ft. on shores of Mahadev Lake, rich in aquatic insects.

slender, about two and a half times as long as the second segment, somewhat swollen subapically and about nine times as long as thick, its diameter slightly less than half that of the second segment. Antennae (Figs. 10, 11) black, with 14 segments, segments cylindrical; circumfila dense, forming a net-work of complicated anastomosing branches; scape short, stout, brownish, length about one-fourth the thickness; pedicel dark brown to black, subglobose, its diameter somewhat less than that of scape; third antennal segment about a little more than three times as long as thick and a little more than twice the length of scape; fourth antennal segment nearly three-fourths the length of the third; segments five to seven each nearly equal to fourth; segment eight slightly shorter; segments nine, ten, eleven and twelve each equal to eighth; thirteenth segment slightly shorter and a little more than half the third segment; fourteenth segment nearly half the third. Wing as in fig. 13. Vein R_5 reaching margin of wing at apex. Legs long, blackish-brown to black, lenders, metatarsus nearly one-third the second tarsal segment; third tarsal segment about half the second; fourth segment about three-fifths the third; fifth tarsal segment about two-thirds the fourth. Claw simple, stout, strongly curved. Empodium equal to claw. Genitalia (Fig. 14) small, very dark brown. Dorsal plate with a cup-shaped apical incision, the lobes obtusely triangular, short. Ventral plate very slightly longer, with shallow incision, lobes short, narrow. Basal clasp segment stout, simple, strongly curved dorsally. Terminal clasp segment stout, shorter than basal clasp segment, subapically closely pectinate. Style short, less than half the basal clasp segment, longer than ventral plate, moderately stout.

Female.—Length 4.5 mm. Black. Densely setose, scaled. Eyes confluent above. Trophi normal. Palpus (Fig. 6) moderately, long, triarticulate; first palpal segment short, subcordate to obpyriform, nearly as long as thick; second palpal segment somewhat longer than the first and almost twice its own diameter; third palpal segment a little less than twice the second but more slender, apical half as thick as at base and about eight times as long as thick apically. Antennae (Figs. 7-9) black, with 14 cylindrical segments and whorls of long setae in addition the usual pubescence; circumfila in reticulum of anastomosing branches, especially crowded in the

257381

apical two-thirds of segments; all segments somewhat narrow basally and stouter apically; scape nearly as long as thick; pedicel oblate and much narrower; third antennal segment elongate, more slender, about eight times as long as thick; fourth segment about half the third segment; fifth antennal segment somewhat shorter; sixth segment about three-fourths the fourth segment; seventh antennal segment equal to the sixth segment; eighth segment somewhat shorter; ninth segment a little shorter than eighth; tenth segment about one-fourth the third segment and slightly shorter than ninth; eleventh segment slightly shorter than tenth; twelfth segment about one-fifth the third; less than twice as long as thick; thirteenth segment short, truncated-conical, about one-tenth the third segment; fourteenth segment greatly reduced and minute. Legs densely clothed with scales. Metatarsus almost one-third the second tarsal segment; third tarsal segment almost half the second; fourth segment nearly equal to metatarsus; fifth tarsal segment about two-thirds the fourth segment. Claw simple, stout, strongly curved, equal to empodium. Ovipositor heavily sclerotised, protractile, aciculate.

Holotype one male, *allotype* one female and *paratypes* males and females. Reared from gall No. 486 on buds of *Indigofera gerardiana* Wall. between 4th and 10th June 1953 from material collected at Kareiri, 10 miles from Dharamsala : Kangra District, 8000 ft. M.S. Mani and Santokh Singh, 4-vi-1953.

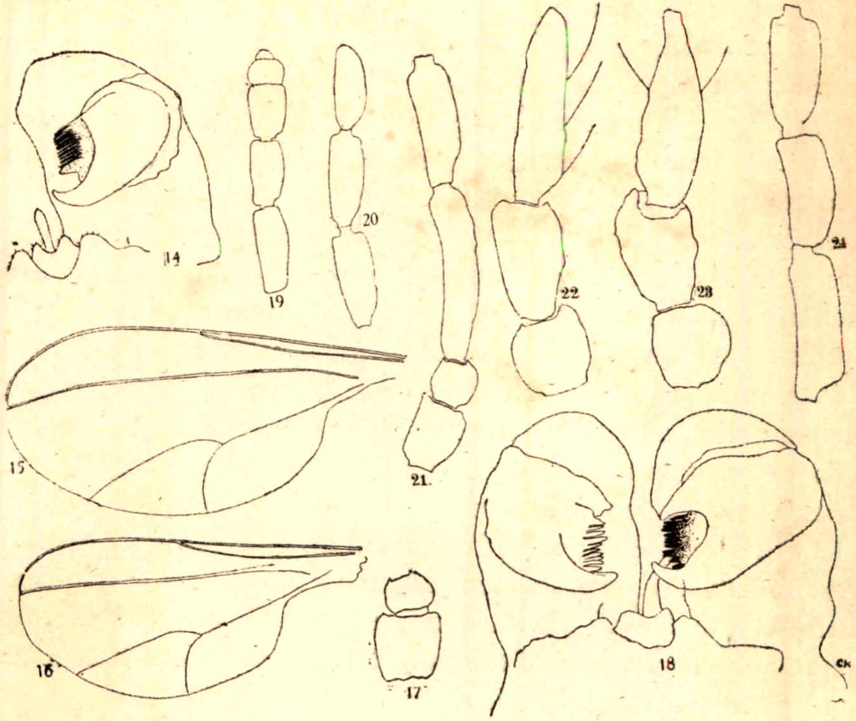
This is the first record of the genus *Oxasphondylia* Felt from India.

Oxasphondylia dosua, sp. nov.

Male.—Length 2.5 mm. Black. First (Fig. 22) palpal segment subglobose, nearly as long as thick; second palpal segment almost twice the first segment; third palpal segment one and one-third the second segment. Antennae (Fig. 17, 20, 24) black, with 14 cylindrical segments; circumfila forming net-work of anastomosing branches; scape subcordate, slightly thicker than long; pedicel oblate, length five-eighths the diameter; third antennal segment nearly thrice as long as thick; fourth antennal segment about three-fourths the third; fifth segment equal to fourth; segments 6 to 11 each equal to fifth; twelfth segment slightly shorter; thirteenth segment a

Dholum , 5000 ft. *Quercus incana* with gall No. 283.

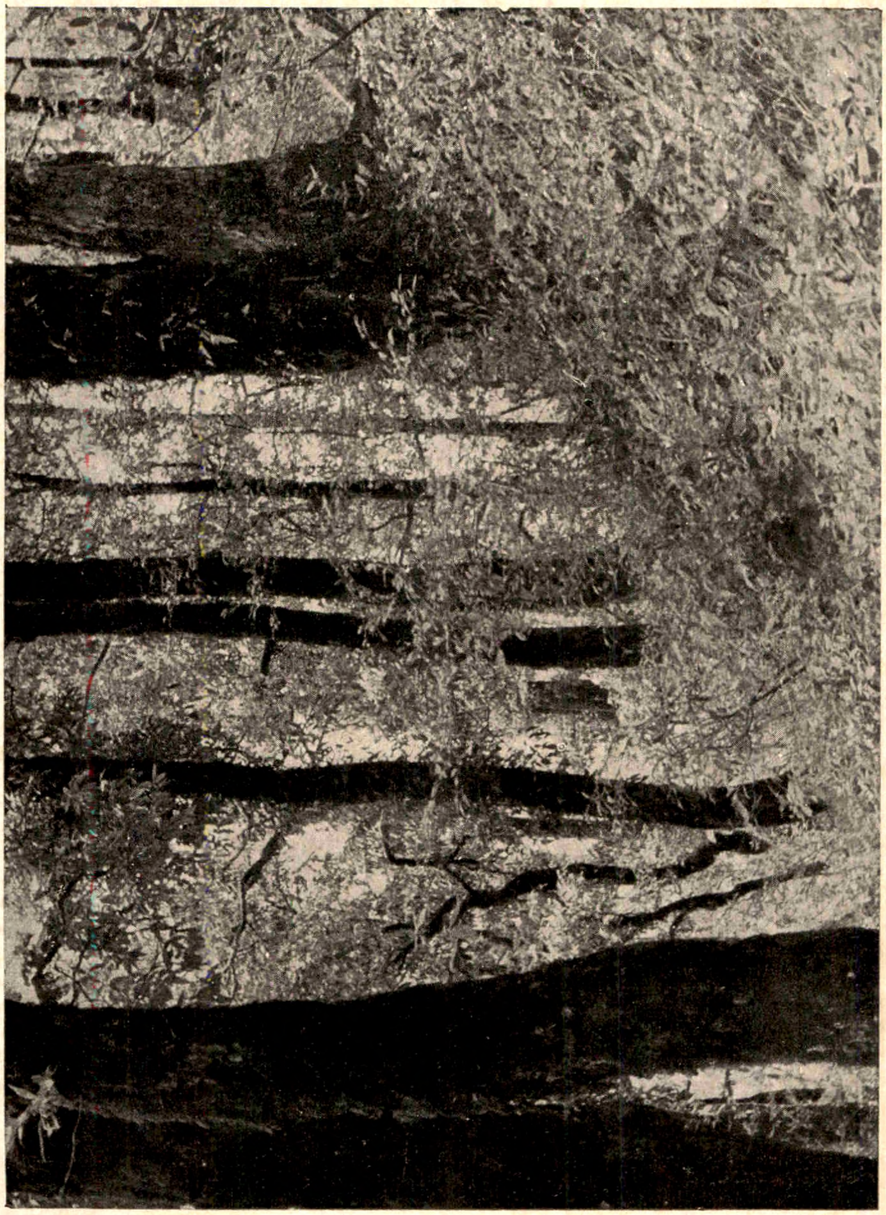
little more than half the third; fourteenth segment somewhat shorter than thirteenth and almost thrice its own diameter. Mesonotum black. Scutellum dark brown. Wing as in fig. 16 Legs slender, elongate, on foreleg metatarsus about one-ninth the second tarsal segment, second tarsal segment about four times the metatarsus, third segment somewhat less than half the second, fourth segment about half the third and twice the metatarsus, fifth tarsal segment slightly shorter. Claw moderately stout, strongly curved. Empodium distinctly shorter than claw. Genitalia small, dark brown (Fig. 18). Dorsal plate apically with a broad shallow incision, the lobes short, obtusely rounded. Ventral plate distinctly longer than dorsal plate, apically with an obtusely triangular shallow incision, the lobes right-angled triangular. Style heavily sclerotised, moderately stout, elongate, curved dorsally and much longer than ventral



14. Male Genitalia, *Oxasphondylia echinata*, sp. nov. 15-24. *Oxasphondylia dosua*, sp. nov. 15. wing, female. 16. wing, male. 17. Scape pedicel: male 18. Male genitalia. 19. Terminal antennal segments, female. 20. Terminal antennal segments male. 21. Basal antennal segments, female, 22. Palpus male, 23. Palpus, female 24. Third to fifth antennal segments, male.

plate. Basal clasp segment moderately stout, curved upward, strongly carinate mesially apically below. Terminal clasp segment short, stout, pectinate apically.

Female.—Length 3.0 mm. Black. Densely setose. Palpus (Fig. 23) short, dark reddish-brown, triarticulate. First palpal segment subglobose; second segment with a length about one and a half times the diameter of the first segment, nearly as thick as the first; third palpal segment elongate-conical, distinctly more slender than second segment, its length nearly twice that of the second segment and about three times its own diameter, apically obtusely rounded. Antennae (Fig. 19,21) black, densely setose, somewhat more than half the length of body, with 14 cylindrical segments, which are somewhat narrowed basally and have whorls of long setae in addition to the usual short pubescence, paler basally than apically; circumfila in close net-work of anastomosing branches; scape somewhat elongate, with a length slightly more than one and one-fourth the maximum thickness; pedicel subglobose, slightly more slender than scape; third antennal segment nearly three times the length of scape and slightly more than four times its own diameter; fourth antennal segment about twice the scape and about two-thirds the length of third segment; fifth antennal segment equal to sixth and nearly of the same length as the fourth segment; seventh antennal segment slightly shorter; eighth antennal segment shorter than seventh; ninth segment half the third and somewhat shorter than eighth; tenth antennal segment slightly shorter; eleventh antennal segment a little more than one-third the third segment; twelfth antennal segment somewhat shorter; thirteenth segment about one-seventh the third and nearly half the twelfth segment; fourteenth antennal segment very small, short, hardly one-third the thirteenth segment and forms a blunt subglobose process on the thirteenth segment. Mesonotum very dark brown. Scutellum brown. Wing densely setose, black, shape and proportions as in fig. 15. Leg short, black, densely setose and scaled; metatarsus about one-fourth the second tarsal segment; third tarsal segment about one and a half times the metatarsus; fourth and fifth tarsal segments each nearly as long as metatarsus. Claw simple, stout, strongly curved. Empodium very slightly shorter than claw. Abdomen about two-thirds the length of body, dark



Forest compartment 13B Kalatop, 8,500 ft. Dalhousie, with Gall. No. 421 on *Quercus incana*, Gall. No. 500 on *Sabia campanulata* and Gall No. 497 on *Rosa macrophylla*.

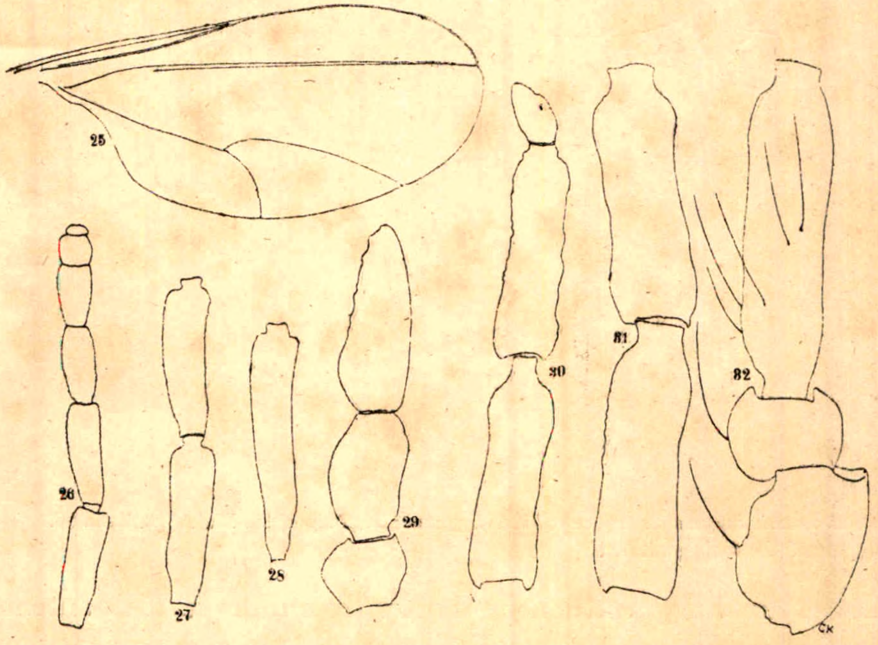
brown, densely clothed with black setae. Ovipositor protractile, aciculate, heavily sclerotised.

Holotype one male and *allotype* one female *paratypes* males and females. Reared from gall No. 483 on branches of *Indigofera dosua* Ham. M. S. Mani, 25. v-14. vi. 1953 from material collected from Dharamsala : Kangra District, M. S. Mani and Santokh Singh.

This species differs from *Oxasphondylia echinata* Mani in its smaller size, in the different proportions of palpal and antennal segments and in the differently organized male genitalia.

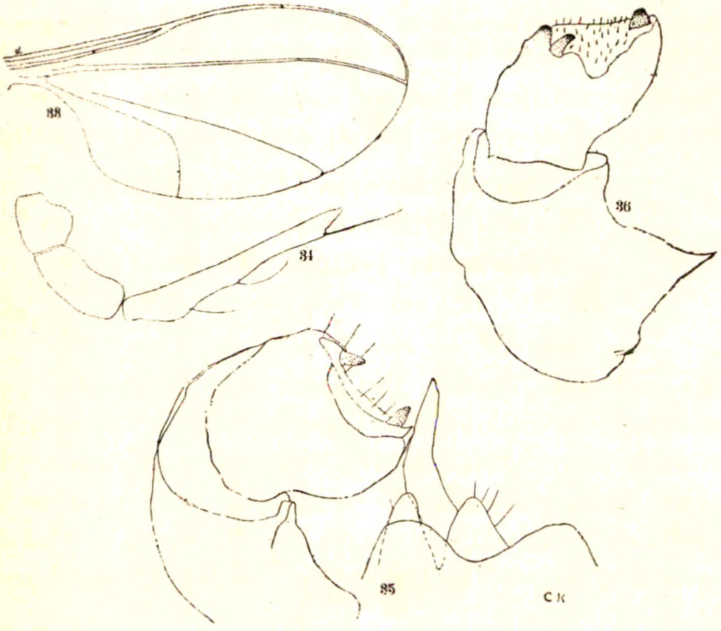
Oxasphondylia floricola, sp. nov.

Female.—Length 3.0 mm. Black, densely setose and scaled. Palpus (Fig. 29) relatively short, reddish-brown, triarticulate; first palpal segment globose; second segment with a length nearly twice the diameter of the first palpal segment and slightly less than twice its own maximum thickness, third palpal segment



25-29. *Oxasphondyia floricola,* sp. nov. 25. wing. 26. Terminal antennal segments. 27. Fourth and fifth antennal segments. 28. Third antennal segment. 29. Palpus. 30-32. *Acroectasis campanulata,* sp. nov. 30. Terminal antennal segments. 31. Fourth and fifth antennal segments. 32. Basal antennal segments.

elongate-oval, with a length almost one and a half times the second, slightly more slender than second. Antennae (Fig. 26-28) black, a little more than half the length of body, with 14 cylindrical segments, somewhat paler basally, with whorls of long setae in addition to the usual short pubescence; circumfila in network of anastomosing branches; scape nearly as long as thick, short, stout; pedicel obliquely cordate and narrower than scape; third antennal segment about five times as long as thick and a little more than three times the length of scape; fourth antennal segment about two-thirds the third segment; fifth antennal segment slightly shorter; sixth segment a little shorter than fifth; seventh antennal segment a little shorter than sixth; eighth antennal segment somewhat shorter than seventh segment and slightly more than one half of the third antennal segment; ninth antennal segment very slightly shorter than eighth; tenth antennal segment about three-fifths the ninth segment; eleventh segment nearly three-fourths the tenth segment; twelfth segment about three-fourths the eleventh segment and nearly one-fourth the length of third antennal



Acroectasis campanulata, sp. nov. 33. Wing, male 34. Palpus, 35. Male genitalia 36. Claspers of the male genitalia.

segment; thirteenth antennal segment about half the twelfth segment; fourteenth antennal segment a short, hemispherical vestige. Mesonotum black. Scutellum lighter brown. Wing as in fig. 25. Legs slender, long, first tarsal segment nearly one-fourth the second, third tarsal segment a little more than half the second; fourth segment about two-thirds the third; fifth segment equal to the first. Claw moderately stout, strongly curved. Empodium very slightly shorter than claw. Abdomen about three-fifths the length of body, black, densely setose and scaled. Ovipositor protractile, aciculate, heavily sclerotised.

Holotype one female reared from gall No. 490 on flowers of *Indigofera gerardiana* Wall. Coll. M. S. Mani, Mrs. M. S. Mani and Santokh Singh, Dalhousie, 8000 ft. 10-18. vi. 1953.

This species differs from the two foregoing species in the different proportions of the palpal and antennal segments.

B. Descriptions of Plant Galls

Natural Order Berberidaceae

Berberis lycium Royle

Gall No. 425 on branches by fungus

Mani, 1953. *Agra Univ. J. Res.* (Sci.)2(1) : 136.

This gall is extremely abundant and frequently grows up to sizes varying from 30 mm to 50 mm in diameter on nearly every plant on hills near McLeodgunj, Trihund and other hills near Dharamsala, between altitudes ranging from 6000 ft to 9000 ft. It is specially extremely abundant on the hills north of McLeodgunj and Dharamkot on way to Lakka Pass of the Dholadhar Range.

Natural Order Rhamnaceae

Rhamnus virgata Roxb.

Gall No. 491 on branches and leaves by Ascomycetes

New gall. Diffuse, local, solid, indehiscent tumescence of branches or leaf blade, about 15-20 mm long about 5-8 mm thick, with hypertrophy of cortex; the affected part usually curved or abruptly bent. On surface of mature galls bright orange-red spore tubes of the fungus.

Locality Dalhousie, 6750 ft. Coll. Mrs. M. S. Mani, 11.vi.1953. Rather rare.

Natural Order Vitaceae

Vitis semicordata Wall.

Gall No. 432 by unknown midge on branches

Mani, 1953. *Agra Univ. J. Res.* (Sci.)**2**(1) : 139.

Very immature galls deep reddish to reddish-brown just forming on branches, tendrils and petioles in several localities in Dalhousie 7500 ft. during late June 1953.

Natural Order Sapindaceae

Aesculus indica Colebr.

Gall No. 504 by *Eriophyes* sp. on leaf

New gall. Regular, local, free, epiphyllous, large, shallow, cup-like, smooth, yellowish-green beutelgalls on leaf blade, about 20 mm long and 10 mm wide, 5-8 mm high; upper surface of the gall with obscure fleshy tubercular elevations; gall cavity large, wide open hypophyllous ostium, with pit-like depressions covered by dense brown erineum.

Locality Dalhousie, 6790 ft. Coll. Mrs. M. S. Mani & Santokh Singh, 25. vi. 1953.

Natural Order Sabiaceae

Meliosma rigida S. Z.

Gall No. 485 by unknown midge on leaf

New gall. Regular, epi- or hypophyllous, local, or diffuse, subglobose or fusiform, solid, indehiscent tumescence of the midrib and bases of the larger lateral veins, about 5 mm in diameter; smooth, brown. Larval galleries irregular. Young galls arise as local lateral obtusely conical short cortical emergences but soon extend to deeper parts and become diffuse growths.

Locality Hills near McLeodgunj : Dharamsala ; Kangra District, 5500 ft. Coll. M. S. Mani, 1.vi.1953.

PLATE VII

FIG. 1-2. Gall No. 500 on *Sabia campanulata* Wall. by *Acroectasis campanulata* Mani.

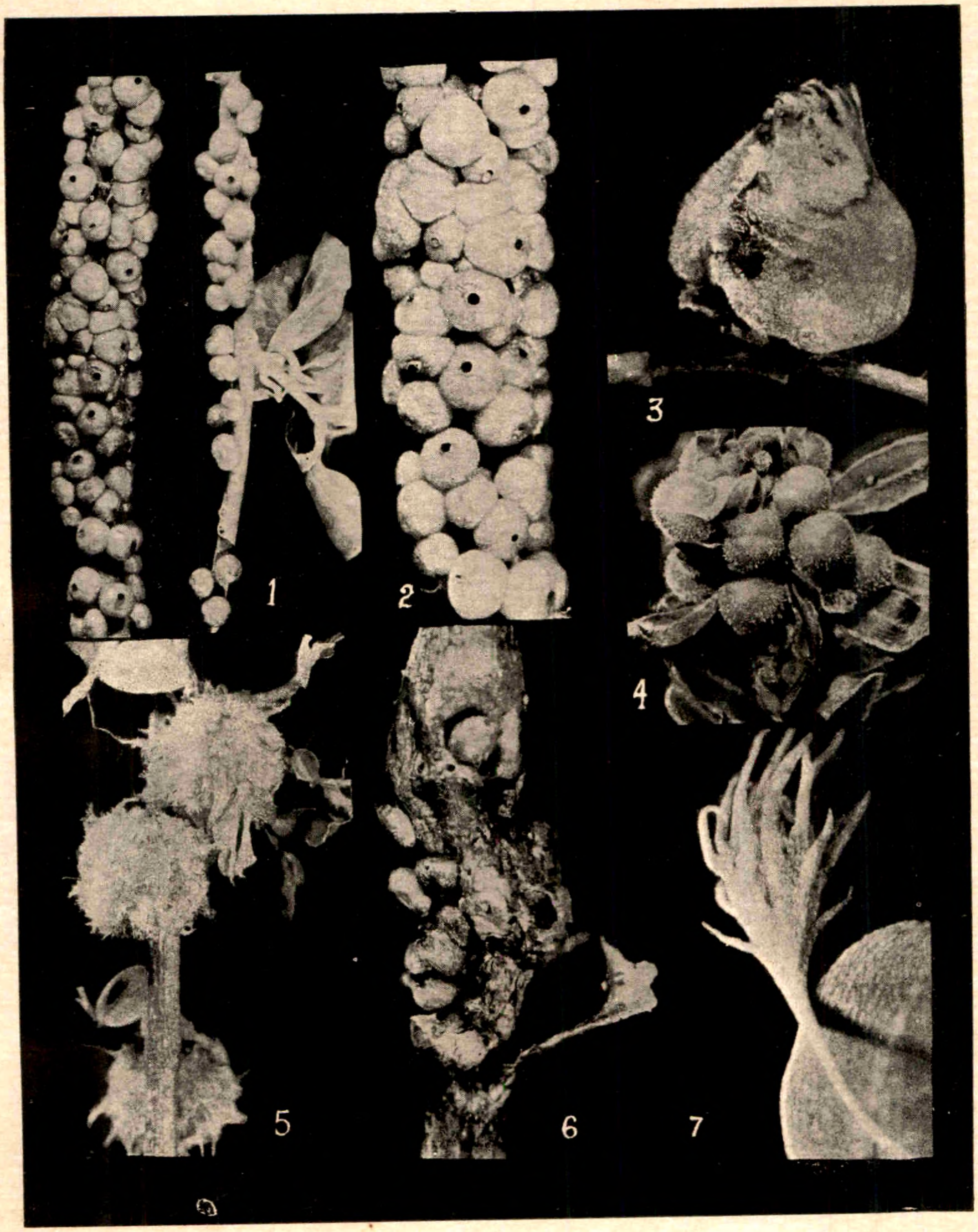
FIG. 3. Gall No. 490 on flowers of *Indigafera gerardiana* Wall. by *Oxasphondylia floricola* Mani.

FIG. 4. Gall No. 503 on *Indigofera gerardiana* Wall.

FIG. 5. Gall No. 486 on *Indigofera gerardiana* Wall. by *Oxasphondylia echinata* Mani.

FIG. 6. Gall No. 484 on *Indigofera dosua* Mani.

FIG. 7. Gall No. 487 on *Indigofera gerardiana* Wall.



M. S. Mani : Plant Galls from Himalayas.

Sabia campanulata Wall.

Gall No. 500 by *Acroectasis campanulata* Mani on branches

(Plate VII)

New gall. Regular, free, globose, sessile, solid, indehiscent, fleshy, green, glabrous, persistent, epidermal, and subepidermal or cortical galls on stem and petioles, 5 mm in diameter, conspicuously crowded in very large numbers all round the branches and usually becoming partially fused basally with each other, curiously looking like a spike of pepper fruits; with a single vertical, narrow cylindrical axiate larval cavity, opening on the surface by a regular circular aperture about 0.5-1.0 mm in diameter and covered by a thin operculum of callus epidermal cells before emergence of the adult midge. The galls occur continuously for several feet on the branch. Gall epidermis of rectangular flat somewhat hypertrophied cells. The bulk of the gall is composed large closely packed, hypertrophied, multinucleate parenchyma cells. The cells near the larval cavity with large conspicuous crystals. Larval cavity lined by callus cells, outside which is the zone of the socalled nutritive cells. Secondary vascular elements develop from base of gall parenchyma and surround loosely the larval cavity and later connect up with the vascular ring of the stem.

Locality Reserve Forest Compartment No. 26,13 B about one and a half miles south of Forest Rest House, Kalatop 8 miles from Dalhousie, on southern aspects of hills, 7000 ft. Coll. M. S. Mani & Santokh Singh, 18. vi. 1953.

Natural Order Leguminosae

Desmodium sp. (?)

Gall No. 488 by unknown weevil on branch

New gall. Regular, local, diffuse, fusiform or oval, indehiscent, persistent, solid, smooth, cortical tumescence of branches, about 10-20 mm long and 5 mm thick, with one large, cylindrical, oblique larval cavity containing a single prepua of the weevil.

Locality Kareiri 8 miles from Dharamsala 6800 ft. Coll Santokh Singh, 4. vi. 1953.

Indigofera dosua Ham.

Gall No. 429 by unknown midge of leaf

Mani. 1953. *Agra Univ. J. Res.* (Sci.) **2** (1) : 141.

Undergrowth in oak forest in Dholum near Dharamsala. Coll. M. S. Mani, 22-v-1953. Rather rare.

Gall No. 431 by *Eriophyes* sp. on leaf.

Mani. 1953. *Agra Univ. J. Res.* (Sci.) **2** (1) : 140.

This gall is rather scarce during the summer but a few isolated plants, especially near the banks of streams, had some galls. These examples were restricted to the Dholum oak Forest near Dharamsala in May.

Gall No. 483 by *Oxasphondylia dosua* Mani on branch

New gall. Regular, simple, free, sessile or 2-3-agglomerate, hollow, indehiscent, persistent, unilocular, globose, or subcordate, greenish, almost glabrous but often also with scaly tips of leafy vestiges, thin-walled branch galls, similar to gall No. 429 on the same plant described in an earlier paper (*loc. cit.*), single galls about 6-7 mm in diameter, agglomerate galls 7-10 mm in diameter; exit holes terminal and circular.

Locality McLeodgunj, Kareiri and other localities near Dharamsala, between 6000—8000 ft, extremely abundant and widely distributed; also Dalhousie. Coll. M. S. Mani & Santokh Singh, May-June 1953. Two male and one female of the gall midge and several examples of Hymenopterous parasites emerged between 25. v and 14. vi 1953.

Gall No. 484 by unknown midge on branch

(Plate VII)

New gall. Regular, subepidermal, oval or pyriform or oval, hollow, unilocular, sessile, cortical galls, initially wholly developing concealed underneath the bark from the cortical cells, with gall cavity oval, large, axial; the wall of the gall fleshy, thick, green, parenchymatous, glabrous; nearly 5 mm long and 3 mm in thickness. Very large numbers of these bodies develop close together and the branch becomes conspicuously swollen into a fusiform or elongate-globose swelling, bursting the bark in irregular patches above and at the sides due to the pressure of the galls developing beneath and exposing the nodular galls. This also permits the emergence of the midges. The galls thus develop on branches for nearly 150-200 mm length. The old galls generally persist after the bark has fallen off completely. This gall resembles in development gall No. 457 on *Indigofera pulchella* Roxb., described in an earlier paper (*op. cit.*, p. 142), but lacks trichomes.

Locality On hills near McLeodgunj 5500—6000 ft. Dharamsala, Coll. Santokh Singh, 21. v-1. vi 1953; also sparsely in isolated patches in Forest Compartment No. 22, Reserve Forest 2 miles east of Kalatop Forest Rest House, 8000 ft. Coll. Santokh Singn, 18. vi. 1953.

Indigofera gerardiana Wall.

Gall No. 486 by *Oxasphondylia echinata* Mani on axillary bud

(Plate VII)

New gall. Regular, free, sessile, simple or 2-3-agglomerate, indehiscent, persistent, globose, thick-walled, unilocular, fleshy, galls on axillary buds, about 15-20 mm in diameter, pale green to greenish-white or also sometimes cottony-white; covered by dense, elongate, slender, fleshy, cylindrical or somewhat flattened pubescent, scaly or leafy vestiges and outgrowths and also with dense white, simple villous hairs, giving a curious appearance of the bedeguar on rose. Gall cavity central, globose, with a single larva or pupa of the gall midge. The emergence hole covered by thin scaly skin that is pushed off by the adult fly. The gall is extremely abundant and single branch often bears as many 50 galls. The wall of the gall is composed of large, simple, close parenchyma cells, with vascular elements scattered irregularly. The larval cavity is surrounded by a thin zone of thick-walled mechanical cells.

Locality Hills in Kareiri between 7000 ft. and 8000 ft. rather rare at 65000 ft. Coll. Santokh Singh, 4. vi. 1953; also isolated examples in Upper Bakrota 8000 ft. and Ala Catchment Area Reserve Forest 9500 ft. near Dalhousie, Coll. Santokh Singh, 19-26. vi. 1953.

Gall No. 487 by unknown midge on inflorescence axis

(Plate VII)

New gall. Regular, elongate-oval or fusiform, hollow, simple, indehiscent, petiolate, persistent, utricular, thin-walled, unilocular galls on the main inflorescence axis, which becomes stunted. Each gall bears externally a number of elongate, thin, needle-shaped yellowish-green outgrowths. Gall cavity with a single pupa of the midge. Emergence hole apical. Each gall measures about 8 mm long and 4 mm thick.

Locality Karriri 6000—8000 ft. Coll. Santokh Singh, 4. vi. 1953; also a few isolated examples, Dalhousie, Kalatop Forest area, Coll. Santokh Singh 18-vi-1953.

Gall No. 490 by *Oxasphondylia floricola* Mani on flower

(Plate VII)

New gall. Regular, simple, free, solitary, petiolate, cordate to subglobose, solid, indehiscent, fleshy, smooth or finely pubescent, pale red to yellowish-green or also white swellings of flowers, about 10-12 mm in diameter, formed of the greatly deformed, swollen and unopened calyx, corolla, stamens and pistils. The petals represented by scaly envelops apically on the surface. Numerous larvae of the midge in galleries in between the fused floral leaves, which are wholly parenchymatous and are also covered by fine short, dense, white pubescence. The galls are extremely abundant and widely distributed.

Locality Dalhousie 7000 8000 ft. Coll. M. S. Mani & Santokh Singh, 10-20. vi. 1953.

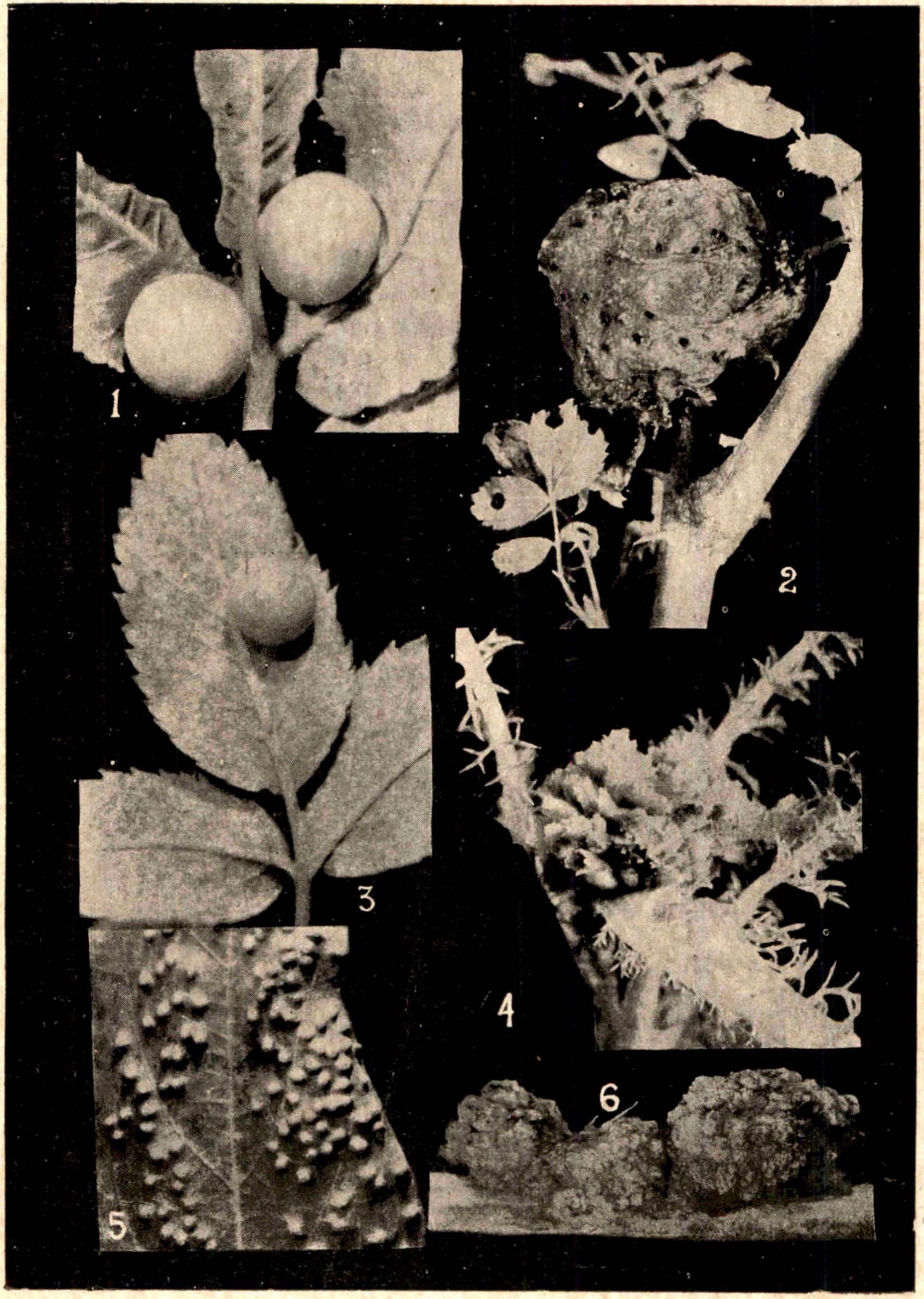
Gall No. 494 by *Eriophyes* sp. on leaflet

New gall. Epiphyllous, subglobose beutelgalls on leaflets, similar to gall No. 431 on *Indigofera dosua* and rather scarce during May-June in Dharamsala and Dalhousie.

Gall No. 503 by unknown midge on rachis

(Plate VII)

New gall. Globose, hollow, thin-walled, green or pinkish-red, indehiscent often agglomerate galls on leaf rachides, similar to gall No. 429 on *I. dosua*, and measuring about 6-10 mm in diameter, with a single pupa. Surface smooth.



M. S. Mani : Plant Galls from Himalayas.

Locality Dalhousie 6750-75000 ft. Coll. Mrs. M. S. Mani, 24. vi. 1953.

Natural Order Rosaceae

Rosa macrophylla Lindl.

Gall No. 497 by unknown cynipid on branch

(Plate VIII)

New gall. Nearly regular free, axillary or terminal, subglobose, solid, hard, woody, indehiscent, persistent, greenish to deep pinkish or pinkish-brown, smooth but with irregular, numerous fleshy spines, and leafy vestiges, with a large number of circular, small exit holes scattered irregularly on the surface of mature galls. The gall is formed on the entire axillary bud or terminal bud and measures from 15 to 25 mm in diameter when mature. Larvae numerous in small oval chambers scattered throughout the interior.

Locality Reserve Forest Compartment No. 23 Kalatop, 6 miles from Dalhousie, 8000 ft. Coll. M. S. Mani & Santokh Singh, 17-19. vi. 1953; also Sankaracharya Hill, 6000 ft. Srinagar and Pir Panjal Range : Kashmir 9000 ft. Coll. M. S. Mani, Santokh Singh & S.R. Kalyan, 27. x. 1953.

Gall No. 499 by unknown cynipid of leaf

(Plate VIII)

New gall. Regular, hypophyllous, simple, sessile, free, solitary, globose, smooth, yellowish or pinkish, solid, fleshy to hard, unilocular, indehiscent, galls about 5 mm in diameter, with an obscure fleshy short mucronate process apically. Gall cavity large, central, with a single larva of the cynipid, 3-4 galls on each leaflet. The thick wall of the gall is composed of simple, closely packed parenchyma cells.

Locality Reserve Forest Kalatop 7 miles from Dalhousie, 8000 ft. Coll. M. S. Mani and Santokh Singh, 18. vi. 1953.

Natural Order Saxifragaceae

Deutzia staminea R. Br.

Gall No. 496 by unknown midge on leaf

New gall. Regular, simple, free, sometimes 2 galls agglomerate, mostly eyiphyllous, circular, biconvex-discoid, reddish-brown, hollow, unilocular, thin-walled, indehiscent, utricular beutelgalls, partly visible on the lower side of the leaf blade also. The epiphyllous part of the gall thicker than the lower. Gall cavity large, with a single pupa of the gall midge or its parasite. Gall size varies from 3-4 mm in diameter to 2-3 mm height. The discolourisation of the gall extends somewhat outside the limits of proliferated part right round in the neighbouring healthy leaf surface also.

Locality Dalhousie 7000 ft. Coll. Santokh Singh, 15-vi-1953.

Natural Order Rubiaceae

Galium mollugo Linn.

Gall No. 435 by unknown midge on bud

Mani. 1953, *Agra Univ. J. Res.* (Sci.)**2**(1) : 144.

A few examples of this gall were collected on the hills near McLeodgunj : Dharamsala, 5500-6000 ft. in May.

Natural Order Compositae

Achillea millefolium Linn.

(Plate VIII)

Gall No. 505 by *Rhopalomyia* sp. (? *millefolii*) on bud

Trotter. 1908. *Marcellia*, **7**:89, No. 6, pl. i, fig. 4; Houard. 1923. Les Zoocecidies des plantes d' Afrique, d' Asie et d' Oceanie, 867, No. 3153.

Irregular, solid, fleshy, terminal bud rosette gall, about 15-20 mm in diameter, pale green or yellowish-green, with numerous fleshy bud-like tubercles and imbricating leafy vestiges.

This gall has been originally described from China and is being recorded here for the first time from India.

Locality Reserve Forest, Ala Catchment Area, 7500 ft. Dalhousie, Coll. Santokh Singh, 26-vi-1953.

Gall No. 527 by *Rhopalomyia millefolii* (H. Low) on leaf, axillary bud, etc.

Houard. 1923. Less Zoocecidies des plantes d'Afrique, d'Asie et d'Oceanie, 867, No. 3152, fig. 1804-1805.; Ross & Hedicke. 1927. Die Pflanzengallen Mittel- and Nordeuropas, p. 76-77, No. 56, fig. 10, 11; Rubsaamen & Hedicke. 1938. Die Cecidomyiden und ihre Cecidien, pp. 288-289, pl. xxiii, fig. 8—11.

Regular, subcylindrical or vase-shaped, epiphyllous, fleshy, unilocular, solid, indehiscent, sessile, free and solitary, frequently crowded together or also agglomerate galls on rachides, petioles, axillary buds, branches, etc., about 3 mm long and 1-1-5 mm thick, smooth, with dentate leafy processes apically surrounding the emergence hole. Each gall with a single pupa in a basal larval cavity, leading above by a narrow tube to the emergence hole.

This gall is previously known from Egypt and Europe and is being recorded here for the first time from India.

Locality Reserve Forest, Ala Catchment Area, 7500 ft. Dalhousie, Coll. Santokh Singh, 26-vi-1953.

Artemisia vulgaris Linn.

Gall No. 445 by unknown midge on leaf

Mani. 1953. *Agra Uni. J. Res.* (sci.) **2** (1) : 147

A few immature examples of this gall were found on north face of hills in Upper Bakrota, Dalhousie, 8000 ft. on 25-vi-1953.

Natural Order Ericaceae

Xolisma ovalifolium (Wall.) Rehd.

Gall No. 502 by *Eriophyes* sp. on leaf

New gall. Irregular, extensive, reddish-brown growth of epidermal cells on leaf blade, veins and midrib into dense petiolate, compound, clavate, irregularly globosely branched, greatly swollen erineal agglomerate emergences, leading to leaf-curling when severe. On superficial examination these emergences present a curious resemblance to conidial spore of fungi. The mites occur on and in between the emergences.

Locality Dalhousie, 6750 ft. Coll. Mrs. M. S. Mani, 23-vi-1953.

Natural Order Oleaceae

Jasminum dispermum Wall.

Gall No. 439 by unknown midge on branch

Mani. 1953. *Agra Univ. J. Res.* (Sci.) **2**(1):150.

This gall is extremely abundant in various localities in Dharamsala, between 4000 ft. and 5000 ft. but most of the galls are immature during May and early June. This is perhaps one of the commonest galls in the Kangra Valley.

Natural Order Acanthaceae

Strobilanthes dalhousianus Clarke

Gall No. 419 by *Eriophyes* sp. on leaf

Mani. 1953. *Agra Univ. J. Res.* (Sci.) **2** (1):150.

This gall is relatively scarce in Dharamsala during May and June, but a few examples were collected at lower altitudes, especially in moist situations. It is also moderately abundant in Dalhousie, particularly above 7000 ft. in June. Some of the examples differ from the typical form, described in an earlier paper (*loc. cit.*) in being clavately enlarged apically.

Natural Order Amarantaceae

Cyathula tomentosa Moq.

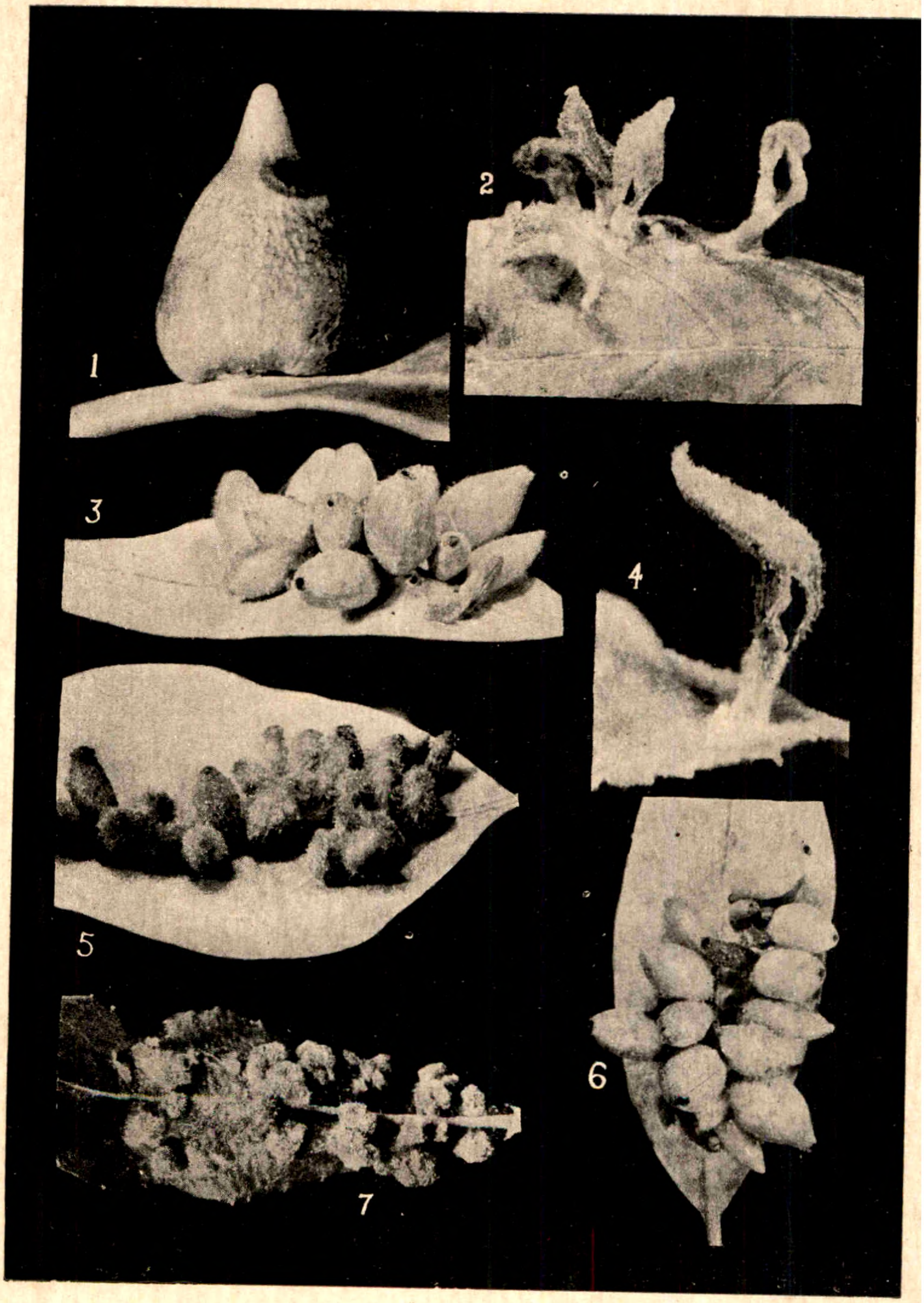
Gall No. 506 by *Eriophyes* sp. on branch

(Plate VIII)

New gall. Irregular, localised or extensive, worty, solid, rough, dark reddish-brown, indehiscent, persistent, hard, fleshy, unilateral, epidermal or cortical outgrowths about 50 mm long and 20 mm in diameter, on petioles, branches, etc. Superficially covered by a moderately thick layer of dead cells, beneath which the mass of gall comprises small closely packed parenchyma cells with irregular vascular elements.

PLATE IX

Fig. 1. Gall No. 482 on *Machilus odoratissima* Nees.
Fig. 2 & 4. Gall No. 493 on *Ulmus wallichiana* Planch.
Fig. 3 & 6. Gall No. 481 on *Machilus odoratissima* Nees.
Fig. 5. Gall No. 479 on *Machilu ordoratissima* Nees by *Neolasioptera* sp.
Fig. 7. Gall No. 492 on *Salix elegans* Wall. by *Eriophyes* sp.



M. S. Mani : Plant Galls from Himalayas, Locality Near Lakka pass 10,000 ft. on Dholadhar Range, 8 miles from Dharamsala, Coll. Santokh Singh, 25. v. 1953.

Natural Order Lauraceae

Machilus odoratissima Nees

Gall No. 479 by *Neolasioptera* sp. on leaf

(Plate IX)

New gall. Regular, hypophyllous, free, solitary, solid, indehiscent, shortly petiolate, oval or subpyriform, unilocular, hard, fleshy, red, densely tomentose beutelgalls, about 15 mm long and 8 mm thick. As many as 50 galls form crowded close together in a bunch on a single leaf. On the upper surface of the leaf blade the site of the gall is indicated by an obscure, acute, fleshy, short mucronate process. The tomentose hairs long, simple, closely matted together, deep reddish. Gall cavity elongate-ovate or cylindrical, axial. Emergence hole apical. The leaf tissues hypertrophied and partly undifferentiated round the site of insertion of the gall. The vascular elements of the gall derived from those of the adjacent veins.

Locality Dharamsala, 4513 ft. Coll. M. S. Mani & Santokh Singh, May-June 1953. This is one of the commonest galls in the locality.

Gall No. 481 by unknown midge of leaf

(Plate IX)

New gall. Regular, hypophyllous, free, solitary, shortly petiolate, solid, hard, fleshy, indehiscent, oval or stout fusiform, green, smooth, unilocular galls, about 15 mm long and 8 mm thick, with a few scattered short fine pubescent hairs. Site of the gall on the upper surface of the leaf blade indicated by an obscure minute fleshy discolourised bulge. Several galls, often as many as 15 clustered together on a single leaf. Gall cavity axial, narrow, cylindrical, straight and opening apically as exist holes and surrounded by a zone of thick-walled cells. This gall is relatively sparse.

Locality Dharamsala, 4513 ft. Coll. M. S. Mani & Santokh Singh, May-June 1953.

Gall No. 482 by an unknown psyllid on leaf

(Plate IX)

New gall. Regular, epiphyllous, free, solitary, cordate, pyriform or shortly conical, hard, unilocular, thick-walled indehiscent, sessile, persistent, reddish-brown to dark brownish, smooth glabrous beutelgalls near one of larger veins and mostly on the midrib or petiole, about 15 mm long and 6-8 mm thick, apically produced into a more or less long, slender, often curved, nipple-like process. Site of the gall is indicated on the opposite side by a small discolourised spot. Gall cavity large, with reticulately veined inner surface and a single nymph of the psyllid. In the gall cavity is often found the caterpillar of an unknown lepidopteran that bites its way in and feeds on the gall substance and finally pupates within the partly damaged gall, in which the psyllid nymph may or may not survive.

This gall much more scarce than the two preceding ones.

Locality Dharamsala, 4513 ft. Coll. M. S. Mani & Santokh Singh, May and June 1953.

Gall No. 495 by an unknown aleurodid on leaf

(Plate VIII)

New gall. Epiphyllous beutelgalls similar to gall No. 440 on *Phoebe lanceolata*, described in an earlier paper[1] , but rather rare and found only in isolated patches on some trees in Dharamsala.

Natural Order Moraceae

Ficus foveolata Wall.

Gall No. 426 by unknown midge of leaf

Mani. 1953. *Agra Univ. Res.* (Sci.) **2** (1) : 152.

Immature and nearly mature galls fairly common in several localities in Dharamsala, ranging from 6000 ft. to 8000 ft. but the galls probably mature in July-August.

---

[1] MANI, M. S. 1953. *Agra Univ. J. Res.* (Sci.) **2** (1) : 152.

Ficus roxburghii Wall.

Gall No. 81 by *Pauropsylla* sp. on leaf

Mani. 1953. *Agra Univ. J. Res.* (Sci.) **2** (1) : 152.

This gall is extremely common and occurs in great abundance on nearly every plant on various localities in the Kangra Valley and in Dalhousie.

Ficus scandens Roxb.

Gall No. 480 by *Eriophyes* sp. on leaf

(Plate X)

New gall. Epiphyllous, agglomerate, sessile, nodular or tubercular, subglobose beutelgalls, yellow above and scattered in enormous numbers, often as many 500, on a single leaf, with hypophyllous ostium, covered by bright red or pink-coloured fleshy emergences and erineum. The gall cavity complex, with fleshy emergences and erineal growth. Single gall varying in size from 1 mm to 3 mm in diameter and agglomerate ones often as large as 5 mm wide.

Locality Hill near Melcodgunj, Kareiri and other nearby areas, Dharmasala, 6000 ft. Coll. M. S. Mani, 21. v. 1953.

Natural Order Ulmaceae

Ulmus wallichiana Planch.

Gall No. 493 by an unknown aphid on leaf

(Plate IX)

New gall. Regular, epiphyllous, free, solitary, petiolate, clavate, cephaloneon, lop-sided, hollow, unilocular, utriculate, thick-walled, dehiscent, beutelgalls, deep reddish-brown, with rough, finely pubescent surface, about 15-20 mm long and 5 mm thick. Ostiole hypophyllous, narrow. The gall dehisces by an elongate or irregular sub-basal rupture on one side. The galls are usually inserted near the leaf margin.

This gall resembles the gall on *Ulmus campestris* caused by *Byrsocrypta gallarum* (= *Tetraneura* = *Eriosoma ulmi*) in Europe.*

Locality Dalhousie 8000 ft. Col. M. S. Mani & Santokh Singh, 13. vi. 1953.

Natural Order Fagaceae

Quercus dilatata Lindl.

Gall No. 448 by *Eriophyes* sp. on leaf

Mani. 1953. *Agra Univ. J. Res.* (Sci.) **2** (1) : 155.

This gall is fairly common in several localities varying in altitudes from 7000 ft. to 7500 ft. in Dalhousie and Chamba Reserve Forests. It is particularly abundant in Reserve Forest Compartment No. 13B, Kalatop, 7 miles from Dalhousie, 7500 ft.

Gall No. 450 by unknown cynipid on leaf

This gall is fairly common in isolated patches in Kalatop Reserve Forest areas, especially near the Forest Rest House, 7900 ft.

Gall No. 501 by unknown cynipid on bud

New gall. Oval or subglobose, solid, spongy, multilocular, indehiscent, nearly smooth galls on buds, about 15 mm in diameter and very similar to gall No. 421 on *Quercus incana* Roxb. described in an earlier paper (*loc. cit.*).

Locality Forest Compartment No. 13, Kalatop Reserve Forest Dalhousie, 7500 ft. Coll. M. S. Mani and Santokh Singh, 17-19. vi. 1953.

Old and immature galls were both fairly common.

Quercus incana Roxb.

Gall No. 292 by *Eriophyes* sp. on leaf

Mani. 1953. *Agra Univ. J. Res.* (Sci.) **2** (1):156.

This gall is one of the most abundant in several localities

---

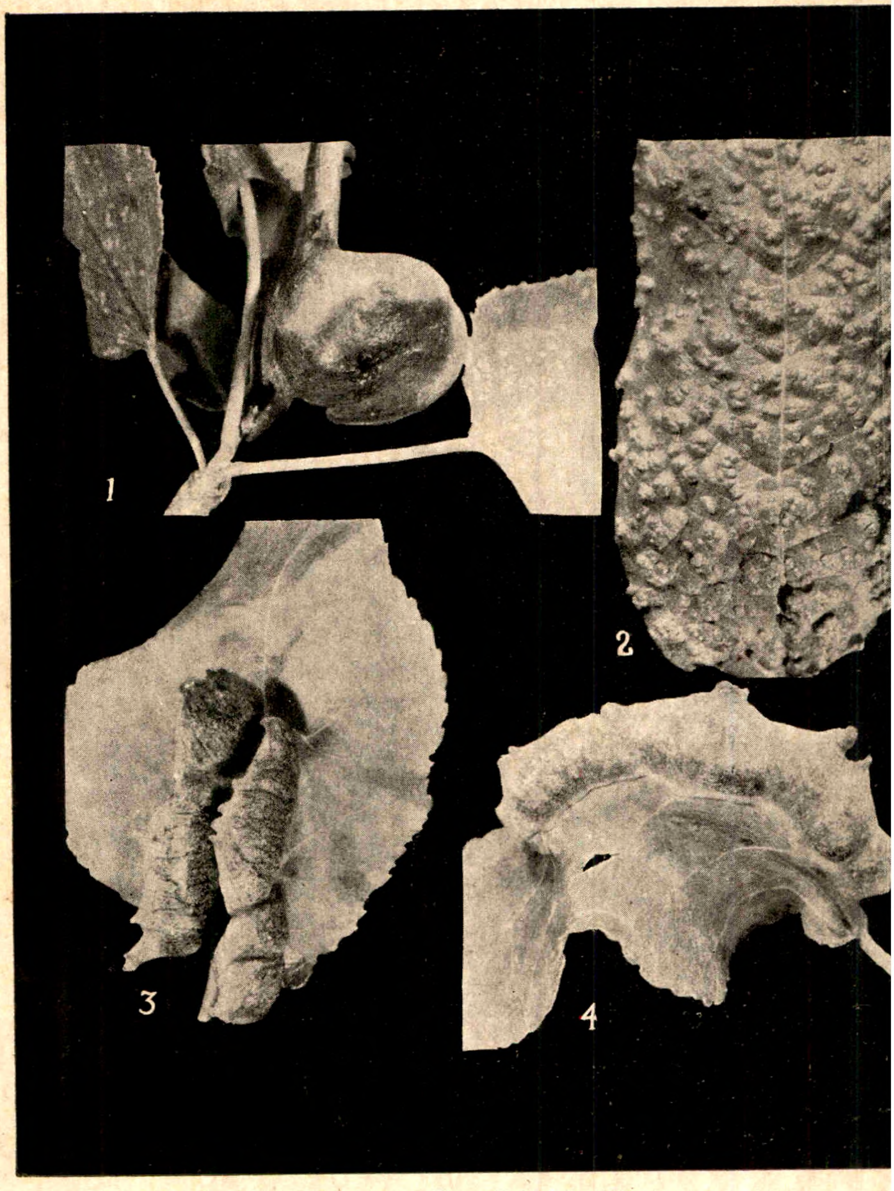
*Ross, H. & H. Hedicke. 1927 Die Pflanzengallen Mittel- und Nordeuropas, p. 290, No. 3844, fig. 230-231.

PLATE X

Fig. 1. Gall No. 115 on *Populus ciliata* Wall. by *Pemphigus mordwilkowi* Cholod.

Fig. 2. Gall No. 480 on *Ficus scandens* Roxb. by *Eriophyes* sp.

Fig. 3 & 4. Gall No. 114 on *Populus ciliata* Wall. by *Pemphigus imaicus* Cholod.



M. S. Mani : Plant Galls from Himalayas.

in Dharamsala and Dalhousie. It is particularly abundant on hills of moderate heights, ranging from 4000 ft. to 6000 ft.

Gall No. 293 by unknown midge on leaf

Mani. 1953. *Agra Univ. J. Res.* (Sci.)2(1):152.

The occurrence of this gall is peculiar; it is rather sparse and is found in isolated patches at altitudes of 6000 ft. near McLeodgunj, but at lower altitudes like Dholum oak forest, it is perhaps the most common gall. Both immature and nearly mature examples were collected, but the midges could not be reared from any of them. The gall does not occur in Dalhousie.

Gall No. 421 by unknown cynipid on bud

Mani. 1953. *Agra. Univ. J. Res.* (Sci.)2(1):158.

This is another extremely common gall in the Kangra valley but during May and June mostly old galls, from which the cynipid adult had already emerged, were collected. Several examples of a chalcid parasite emerged from some of the galls. A minute case-bearing caterpillar tunnels inside the spongy mass of the gall and utilises the epidermal pieces for making the case. The size of the gall often attains over 30 mm in diameter in certain localities near Dharamsala. A few old and dry examples were also taken at 7000 ft in Dalhousie in June.

Gall No. 449 by an unknown cynipid on leaf

Mani. 1953. *Agra. Univ. J. Res.* (Sci.)2(1):157.

This gall is comparatively rare in Dharamsala, but far more abundant in Dalhousie, above 7500 ft. In both the places the gall is generally hypophyllous.

Natural Order Salicaceae

Populus ciliata Wall.

Gall No. 114 by *Pemphigus imaicus* Cholod. on leaf

Mani. 1948. *J. R. Asiatic Soc. Bengal* (Sci.)**14**(2):123.

(Plate X)

This is perhaps the commonest gall in Dalhousie, Himachal and other neighbouring areas and occurs on nearly every plant, often attaining to gigantic sizes, reaching up to over 70 mm long, 3-4 on a single leaf, yellow, yellowish-green or also tinged brown or pink and conspicuous from a distance. The galls were mostly immature in June.

Gall No. 115 by *Pemphigus mordwilkowi* Cholod. on branch

Mani. 1948. *J. R. Asiatic Soc. Bengal* (Sci.) **14**(2):123.

(Plate X)

Mostly immature specimens of this gall were found on isolated patches of trees in Dalhousie. At altitudes of 8000 ft. old galls contained 5-6 specimens of *Coccinella septempunctata.*

Salix daphnoides Willars

Gall No. 418 by unknown midge on leaf

Mani. 1953. *Agra Univ. J. Res.* (Sci.)**2**(1):155.

A few isolated examples of this gall were collected on hill slopes at 7500 ft. in Dalhousie, but the galls were mostly very immature.

Salix elegans Wall.

Gall No. 492 by *Eriophyes* sp. on leaf

(Plate X)

New gall. Regular, epiphyllous, subglobose, free or also agglomerate, fleshy, densely villous, yellowish-green septate, multilocular, sessile beutelgalls, with large hypophyllous ostium, covered by dense white straight erineum. Each leaf often with over 50 galls. Size of the gall ranges from 25 mm in diameter.

Locality Dalhousie, 6000-6750 ft. Coll. M. S. Mani, Mrs. M. S. Mani, Santokh Singh and M. Visvanath. June, 1953.

CONTRIBUTIONS TO OUR KNOWLEDGE OF FIG INSECTS (CHALCIDOIDEA : PARASITIC HYMENOPTERA) FROM INDIA*

V.—ON SEVEN SPECIES OF THE GENUS PHILOTRYPESIS FÖRST. WITH A NOTE ON UNISEXUAL VARIATIONS AND POLYMORPHISM[1]

By K. J. JOSEPH, M. Sc., *Senior Research Scholar, Govt. of India Ministry of Education, School of Entomology, St. John's College, Agra.*

Of the seven species described in this paper, five are new, the remaining two being known forms. The available descriptions of the latter species are inadequate and lacking in proper illustrations. These two species are fully redescribed here with figures. The variable and polymorphic males, met with in five of the species, have been designated forms 1-3. The type specimens of the new species are in the collections of the School of Entomology for the time being.

I gratefully thank Professor M. S. Mani for facilities for work, for confirmation of my identifications and for various other courtesies.

Superfamily CHALCIDOIDEA

Family TORYMIDAE

Subfamily Idarninae

Philotrypesis quadrisetosa (Westwood)

1883. *Sycoscaptella quadrisetosa*, WESTWOOD, *Trans. ent. Soc. London*, 1 : 43-44; 4 : 374-378.
1904. *Tetranemopteryx quadrisetosa*, ASHMEAD, *Mem. Carnegie Mus.*, 1 (4) : 239.
1930. *Philotrypesis quadrisetosa* , GRANDI, *Boll. Lab. Ent. Bologna*, 3 : 50-62 & 179.

Female.—Head, thorax and abdomen fundamentally yellowish-brown; mandibles, ocelli, posterior region of the scutellum and the median part of the metanotum somewhat brownish-red; antennal segments two to thirteen, ovipositor-valves, alar pubescence, the marginal and submarginal veins smoky-brown; abdo-

---

*Contribution No. 41 from the School of Entomology, published with the permission of the Professor of Zoology & Entomology.

[1] Part IV of this series is published in the *Agra Univ. J. Res.*, 2 (2) : 267-280 (1953).

men above each segment with a brownish band; the tail-like part of the abdomen dark brownish above; eyes brownish-black; alar membrane hyaline.

Head (Fig. I, 1) distinctly wider between the external margins of the eyes than long; epistomal margin and related setae as in fig. I, 2; lateral margin forwards of eyes converging and a little over half the longitudinal diameter of the eye; posterior margin behind the eyes convex. Dorsum of head almost glabrous. Eyes large; ocelli three. An imaginary line connecting the anterior ends of the two eyes passes through the posterior third of the antennal toruli. Antenna (Fig. I,3) with thirteen segments, of which three form ring-joints; scape hardly six times as long as thick, distinctly longer than the five following segments combined, with long setae; second segment a little over twice as long as thick,

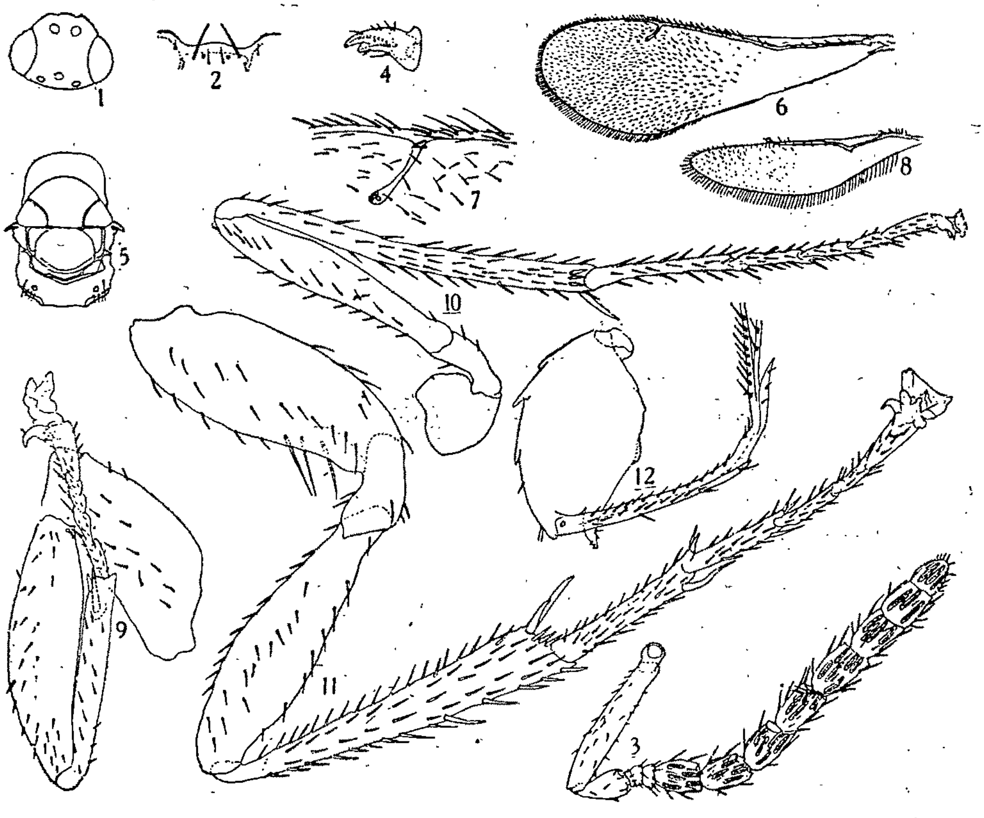


FIG. I.—*Philotrypesis quadrisetosa* (Westwood). Female: 1, head; 2, epistomal margin; 3, antenna: 4, mandible; 5, thorax and propodeum; 6, fore wing; 7, details of stigmal vein; 8, hind wing; 9, fore leg; 10, mid leg; 11, hind leg; 12, abdomen.

narrow basally, thickening distalwards; segments three, four and five form ring-joints which increase in size from the third to the fifth, each with a circlet of setae; sixth one and a half times as long as thick; seventh as long as the sixth but a little less thick; eighth as thick as the sixth but a trifle longer; ninth equal to seventh; tenth equal to sixth; eleventh, twelfth and thirteenth segments form a club of length equal to thrice its own maximum thickness, the three segments decreasing in length distalwards; segments six to thirteen with long and stout sensoria and long setae as in figure. Mandible (Fig. I,4) over one and a half times as long as thick, with acute and long apical tooth, and short, blunt and stout subapical tooth; setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. I, 5). Pronotum with its anterior margin rounded; lateral margins a little diverging posteriorly. Mesonotum with the scutum transversely weakly rugulose, with a few minute setae laterally, distinctly wider than long; scapula moderately convex, transversely and obliquely rugulose, about as long as wide, with a few short setae posteriorly; scutellum flat, wider than stigmal long; axilla subconvex, lateral half inclined outwards, longitudinally rugulose, as long as wide. Length of thorax and propodeum a little more than one and one-third its maximum width. Fore wing (Fig. I, 6) about two and three-fifths as long as its maximum breadth; costal cell about ten times as long as broad; submarginal vein distinctly longer than the marginal; marginal one and four-fifths the postmarginal; postmarginal a little over twice the stigmal; stigmal vein as in fig. I, 7, with four rounded sensillae; marginal fringe long. Hind wing (Fig. I, 8) about four times as long as its maximum breadth, with three frenal hooks; pubescence long anteriorly, very short posteriorly; marginal fringe long. Fore leg (Fig. I, 9): Coxa a little less than two and a half times as long as its maximum width, transversely, obliquely and irregularly rugose, with setae as in figure; trochanter about one and three-fourths as long as wide; femur over thrice as long as its maximum width, longitudinally rugose, with setae and sensillae as in figure; tibia distinctly shorter than the femur, about equal in length to the coxa, seven times as long as its maximum width, with setae, spines and a long bifid spur as in figure. Length of tarsi a little less than three-fourths the tibia; metatarsus shorter than the two following segments combined. Mid leg (Fig. I, 10) : Coxa as long as wide, transversely rugose; trochanter a little longer than twice its width, about one-third as long as the femur; femur over six times as long as wide, transversely and obliquely rugose, with setae as in figure; tibia distinctly longer than the femur and trochanter combined, about thirteen times as long as its own maximum thickness, with long setae, spines and spur. Tarsi shorter than the tibia; metatarsus a little longer than the combined length of the second and third segments. Hind leg (Fig. I, 11) : Coxa about two and two-thirds as long as its maximum width, transversely and obliquely rugose, with many setae and four to five macrochetae on its outer face; trochanter a little over twice as long as its maximum width, one-third as long as the femur, with a few sensillae ventrally; femur three and three-fourths its maximum width, with about five long brownish-black setae on its outer face in a longitudinal line, other setae as in figure; tibia distinctly longer than the femur, but clearly shorter than the combined length of the femur and trochanter, over six times as long as its maximum width, subclaviform, with setae, spines and spurs as in figure. Tarsi distinctly longer than the tibia, with setae and long spines as in figure; metatarsus equal to the two following segments combined. Propodeum three times as wide as its maximum length, transversly weakly rugose, with setae and a pair of spiracles with subrotund peritremes as in figure.

Abdomen (Fig. I, 12). Length upto the seventh urotergite one and four-fifths the height of the abdomen; fifth, sixth and seventh urites with a few setae, the eighth and ninth with many more; eighth urite about as long as the urites three to seven taken together ninth urite about three-sevenths the eighth; projecting part of the ovipositor one and one-fourth as long as the combined length of the urites two to nine; ovipositor-valves strongly setiferous as in figure.

Measurements. Length of body : 3.4 mm.; length of head: 0.40 mm.; width of head (between the external margins of the eyes): 0.53 mm.; length of thorax and propodeum: 0.86 mm.; width of mesothorax : 0.51 mm.; length of urotergites three to seven : 1.10 mm.; length of eighth urotergite : 1.08 mm.; length of ninth urotergite : 0.40 mm.; length of projecting part of ovipositor : 3.3 mm.; length of fore wing : 1.6 mm.; breadth of fore wing : 0.64 mm.; length of hind wing : 1.1 mm.; breadth of hind wing : 0.27 mm.

Male, *Form* 1.—Head brownish-yellow; thorax rusty yellow-brown; abdomen ochraceous; mandibles rusty red-brown; antennal scape and second segment ferrugineous, rest of antenna pale yellow; eyes black.

Head (Fig. II, 13) about one and one-third as wide as long; epistomal margin as in figure; lateral margins converging forwards; the posterior angles largely rounded; posterior margin weakly concave; dorsum of head with small setae, the frontal region pos-

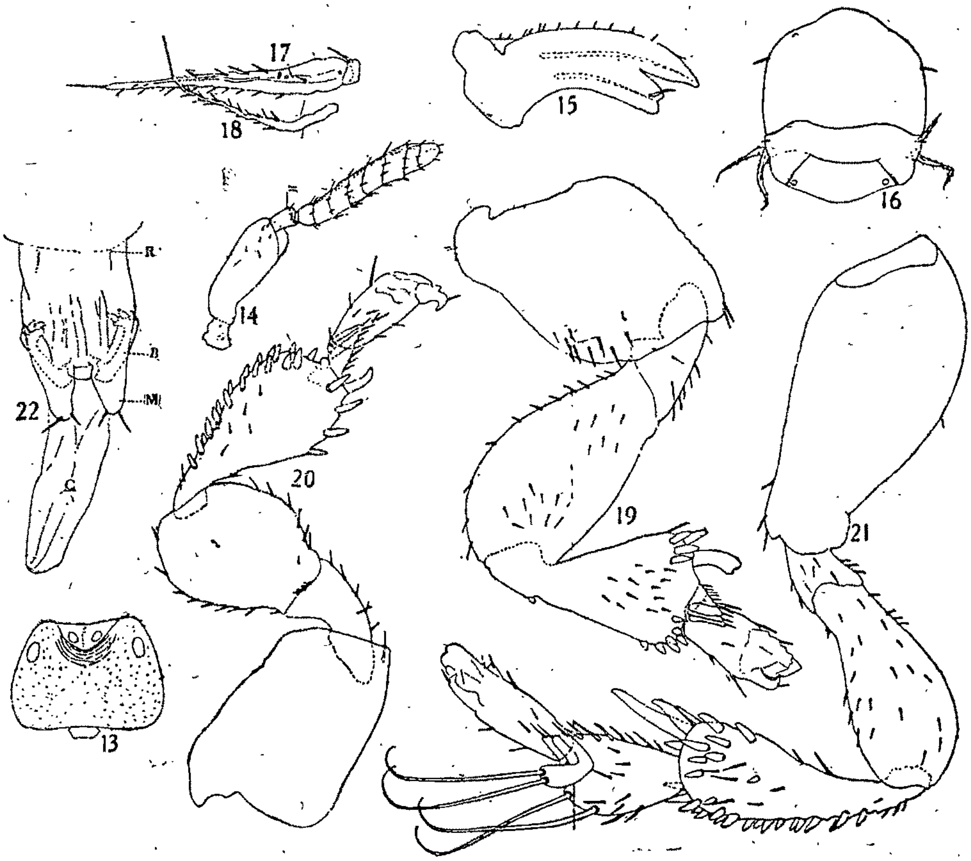


FIG. II.—*Philotrypesis quadrisetosa* (Westwood). Male, Form 1 : 13, head; 14, antenna; 15, mandible; 16, thorax and propodeum; 17, fore wing; 18, hind wing; 19, fore leg; 20, mid leg; 21, hind leg; 22, ventral view of ninth urite, genital armature and penis: R, pseudocerci; B, dorsal appendages; M, ventral processes; C, penis.

terior to the anterior depression inclined with a series of semicircular and irregular rugosities; eyes small. Antenna (Fig. II, 14) with eleven segments; scape a little less than two and a half times as long as its maximum thickness, setae as in figure; second segment less than one-fourth the scape, longer than thick, setae as in figure; third very small, thicker than long, narrow at base; fourth distinctly thicker than long, narrow basally, with a few setae; fifth thicker than long; sixth and seventh equal, thickness a little over one and a half times length; eighth as long as the preceding, one and a half times as thick as long; ninth, tenth and eleventh segments fused to form a club twice as long as its maximum thickness; segments five to eleven with setae and sensoria as in figure. Mandible (Fig. II, 15) large, about two and one-sixth as long as its maximum width, bidentate, teeth and setae as in figure. Maxillary palpus four-segmented ; labial palpus two-segmented.

Thorax (Fig. II, 16). Pronotum one and one-fourth as wide as its median length, hardly a little wider than the head, its lateral margins gently converging posteriorly, anterior margin convex as in figure; rest of thorax and propodeum about twice as wide as its median length; propodeal spiracles with very small rounded peritremes as in figure. Fore wing (Fig. II, 17) longer and broader than the hind wing (Fig. II, 18), setae, sensillae and macrochetae as in figure. Fore leg (Fig. II, 19) : Coxa one and a half times as long as wide, transversely and obliquely rugose; trochanter one and four-fifths as long as wide; femur a little less than twice as long as its maximum width, setae as in figure; tibia a little less than twice as long as wide, with setae, odontoid spines and a bifid spur as in figure. Tarsi a little over half the tibia ; fifth segment two-thirds the tarsal length and one and one-fourth as long as wide. Mid leg (Fig. II, 20) : Coxa one and a half times as long as wide, transversely weakly rugose; trochanter twice as long as wide; femur large, its dorsal and ventral margins arched, one and one-third as long as wide, with setae as in figure; tibia twice as long as wide, with setae, odontoid spines and spur as in figure. Length of tarsi more than half the tibia; fifth segment two-thirds the tarsal length and twice as long as wide. Hind leg

(Fig. II, 21) : Coxa a little longer than twice its width, obliquely weakly rugose; trochanter a little longer than twice its width; femur twice as long as its maximum width, obliquely weakly rugose with setae as in figure; tibia long, over two and three-fourths as long as wide, with setae, odontoid spines and tibial spurs as in figure. Tarsi a little shorter than the tibia; metatarsus distinctly longer than half the tarsal length, its length a little less than twice its maximum width, large and compressed, with two very long macrochetae on its dorsal projecting margin; the second tarsal segment half as long as the first, dorsal margin with two similar macrochetae; fifth segment a little less than three-fourths the metatarsus and wice as long as its maximum width.

Abdomen about one and a half times as long as wide; the eighth urite with a pair of spiracles provided with small rounded peritremes situated laterally as in figure; ninth with two small pseudocerci (Fig. II, 22, R) each with one seta; genital armature with two ventral flattened processes (Fig. II, 22, M) each with two long setae, and two dorsal, depressed, long and distally dilated appendages (Fig. II, 22, B) each provided with three short, stout odontoid spines; penis as in fig. II, 22, C.

Male, Form 2.—Head, thorax and abdomen pale yellowish-brown; mandibles pale brownish-red; legs ochraceous; eyes black.

Head (Fig. V, 50) hardly a little wider than long; epistomal margin as in figure; lateral margins of head converging forwards; anterior and posterior angles of head rounded; posterior margin of head weakly concave; the frontal region posterior to the anterior depression is inclined but almost without any rugosities. Mandible one and three-fourths as long as wide, bidentate, normal.

Thorax with pronotum distinctly wider than long, hardly a little wider than the head; its lateral margins faintly converging posteriorly; anterior margin convex; rest of thorax and propodeum one and one-third as wide as its median length. Fore wing (Fig. V, 51, im) short, broad and stumpy (brachipterous) with a few sensillae; hind wing (Fig. V, 51, ir) long and filamentous, thrice as long as the fore wing, with a few setae. Fore leg (Fig. V, 52) : Coxa a little longer than one and a half times as long as wide, obliquely weakly rugose, with setae as in figure; trochanter about one and three-fourths as long as wide; femur a little less than twice as long as wide; tibia a little shorter than the femur, about one and one-third as long as its maximum width, with setae, odontoid spines and a bifid spur as in figure. Mid leg (Fig. V, 53) : Coxa a little longer than wide; length of trcohanter about twice its width; femur large, its dorsal and ventral margins arched, about one and one-third as long as its maximum width, with a few setae and sensillae as in figure; tibia long, two and three-fourths as long as its width, with setae, odontoid spines and a spur as in figure. Tarsi distinctly longer than half the tibia; fifth segment clearly longer than half the tarsi and about two and one-fourth its own width. Hind leg (Fig. V, 54) : Coxa a little less than twice as long as wide, obliquely weakly rugose; trochanter a little less than twice as long as its width; femur about twice as long as its maximum width with setae and sensillae as in figure; tibia long, about thrice as long as wide, with setae, odontoid spines and spurs as in figure. Tarsi a little longer than the tibia; metatarsus about half as long as the tarsal length, twice as long as its own width, large, subcompressed, its dorsal margin well projecting with two long macrochetae; second segment half as long as the preceding, its dorsal projecting margin with two long macrochetae; length of fifth segment five-sevenths the metatarsus and one and two-thirds as long as its own width.

Abdomen about twice as long as wide; the eighth urite with a pair of spiracles provided with small rounded peritremes situated laterally; ninth with two small pseudocerci, each with a seta; genital armature with two distal, ventral and flattened processes each bearing two long setae, and two dorsal, depressed, long and distally dilated appendages each provided with three short, stout, odontoid spines; penis large, sublanceolate.

MEASUREMENTS

	Male, Form 1.	*Male, Form* 2.
Length of body	2.1 mm.	1.4 mm.
Length of head	0.57 mm.	0.33 mm.
Width of head	0.73 mm.	0.34 mm.
Length of pronotum	0.60 mm.	0.27 mm.
Width of pronotum	0.75 mm.	0.34 mm.
Length of rest of thorax and propodeum	0.36 mm.	0.25 mm.
Width of mesonotum	0.71 mm.	0.34 mm.
Length of abdomen	0.68 mm.	0.55 mm.
Width of abdomen	0.43 mm.	0.23 mm.
Length of fore wing	0.34 mm.	0.05 mm.
Length of hind wing	0.25 mm.	0.16 mm.

Geographical distribution. Collected by K. J. Joseph from the figs of *Ficus asperrima* Roxb. on way to Vazhapara Beat, Pathanapuram, Travancore, dated 25th June, 1951.

Philotrypesis pilosa Mayr

1906. *Philotrypesis pilosa*, MAYR, *Wien. entom. Zeitung*, **25** : 174-175
1926. *Philotrypesis sp.*, GRANDI, *Bull. Soc. Zool. France*, **53** : 79
1928. *Philotrypesis pilosa*, GRANDI, *Treubia*, **8** : 362
1930. *Philotrypesis pilosa*, GRANDI, *Boll. Lab. Ent. Bologna*, **3** : 157-158

Female.—Head, thorax and abdomen with a fundamental yellowish-brown colour; mandibles, ocelli, posterior region of the scutellum and the median part of the metanotum somewhat brownish-red; antennal segments two to thirteen, ovipositor-valves, and the alar pubescence smoky-brown; eyes brownish-black; alar membrane hyaline; nervures amber; the abdomen above each segment with a brownish band; the tail-like part of the abdomen dark brownish above.

Head (Fig. III, 23) distinctly wider between the external margins of the eyes than long; epistomal margin and related setae as in fig. III, 27; lateral margins of head forwards of eyes half the longitudinal diameter of the eye, and converging forwards; posterior margin of head behind the eyes broadly rounded; eyes large; ocelli three; an imaginary line connecting the anterior ends of the two eyes passes through the posterior third of the antennal toruli; dorsum of head with a few minute setae. Antenna (Fig. III, 24) with thirteen segments, of which three form ring-joints; scape about five and three-sevenths as long as its maximum thickness and distinctly longer than the five following segments combined; second segment twice as long as thick; the third, fourth and fifth form ring-joints, each with a circlet of setae and increasing in size from the third to the fifth; sixth as long as the second but distinctly thicker than it; seventh equal in length to the sixth but a little less thick; eighth a little longer and thicker than the preceding segment; ninth equal in length to the seventh but a little less thick; tenth as thick as the seventh but a little shorter; eleventh, twelfth and thirteenth segments form a club of length hardly three and a half times its maximum thickness, the segments decreasing in length from the eleventh to the thirteenth; segments six to thirteen with rows of long, slender sensoria and long setae as in figure. Mandible (Fig. III, 25) twice as long as wide, bidentate; teeth and setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. III, 26). Pronotum with its lateral margins

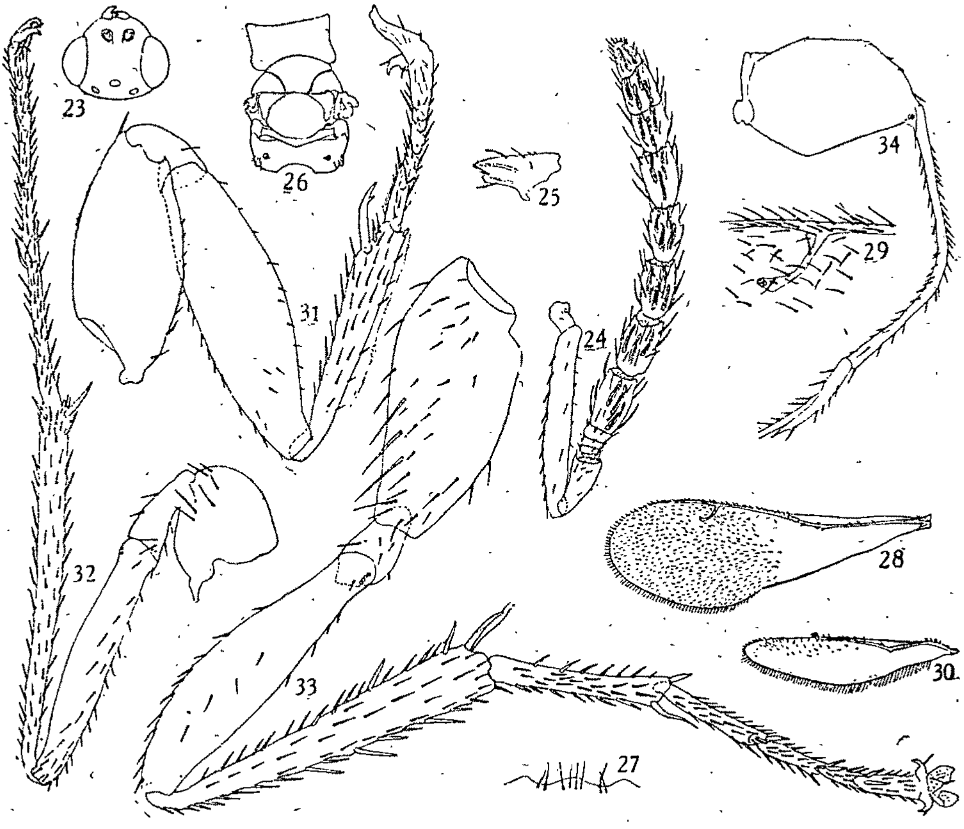


FIG. III.—*Philotrypesis pilosa* Mayr. Female : 23, head; 24, antenna; 25, mandible; 26, thorax and propodeum; 27, epistomal margin; 28, fore wing; 29, details of stigmal vein; 30, hind wing; 31, fore leg; 32, mid leg; 33, hind leg; 34, abdomen.

a little diverging posteriorly, with a few minute setae. Mesonotum with the scutum transversely rugulose, a little less than one and a half times as wide as long, moderately convex anteriorly; scapula weakly convex, transversely rugulose, with a few small setae laterally, a little wider than long; scutellum flat, wider than long, irregularly weakly rugose; axilla a little longer than wide, with a few setae. Length of thorax and propodeum about one and a half times its maximum width. Fore wing (Fig. III, 28) a little more than two and a half times as long as its maximum breadth; costal cell about ten times as long as its greatest width; distal extremity of wing rounded; submarginal vein one and three-sevenths the marginal; marginal one and one-sixth the postmarginal; postmarginal two and a half times the stigmal; stigmal vein as in fig. III, 29, with four rounded sensillae at its distal extremity; pubescence long; marginal fringe of mediocre size. Hind wing (Fig. III, 30) about four times as long as its maximum breadth, with three frenal hooks; alar cuticle with long pubescence in its anterior region and distal extremities, with minute pubescence in the hinder region; marginal fringe moderately long. Fore leg (Fig. III, 31): Coxa a little over twice as long as its maximum width, transversely and obliquely rugose; trochanter one and a half times as long as wide; femur a little over thrice as long as its maximum width, longitudinally weakly rugulose, hardly as long as the coxa and trochanter taken together; tibia distinctly shorter than the femur, a little over six times as long as its maximum width, with long setae, spines and a long bifid spur as in figure. Length of tarsi five-sixths the tibia; metatarsus equal to the two following segments combined; fifth segment equal to the metatarsus. Mid leg (Fig. 32) : Coxa longer than wide, transversely rugose, with setae as in figure; trochanter twice as long as wide, with setae and sensillae as in figure; femur six times as long as wide, with setae as in figure; tibia long, distinctly longer than the femur and trochanter combined, twelve times as long as its maximum width, with long setae, spines and a long spur as in figure. Tarsi shorter than the femur; metatarsus a little longer than the two following segments combined. Hind leg (Fig. III, 33) : Coxa two and a half times as long as its width, transversely and obliquely rugose, with setae and about four macrochetae on its outer face as in figure; trochanter a little over twice as long as wide, with setae and sensillae as in figure; femur a little less than four times as long as its maximum width, with setae, of which about four on the outer face are larger, distinct and disposed in the median longitudinal line; tibia distinctly longer than the femur and much shorter than the femur and trochanter taken together, a little over six times as long as its maximum width, with setae, spines and spurs as in figure. Tarsi distinctly longer than the tibia, with setae and long spines as in figure; metatarsus a little longer than the two following segments combined. Propodeum (Fig. III, 26) three times as wide as its maximum length, transversely rugose, with setae and a pair of spiracles with small subrotund peritremes as in figure.

Abdomen (Fig. III, 34). Length of abdomen upto the seventh tergite one and a half times its height; sixth and seventh urotergites with a few long setae, eighth and ninth with numerous longer and stouter setae; the tail-like part of the abdomen hardly as long as the body without the tail-like part of the abdomen; eighth urite very long, one and three-fifths as long as the abdomen upto the seventh segment; ninth urite a little over one-fourth the eighth; projecting part of the ovipositor one and one-third as long as the urites two to nine; ovipositor-valves strongly setiferous.

Measurements. Length of body : 3.4 mm.; length of head : 0.44 mm.; width of head : 0.53 mm.; length of thorax and propodeum : 0.60 mm.; width of mesothorax : 0.53 mm.; length of urotergites three to seven: 0.95 mm.; length of eighth urotergite 1.50 mm.; length of ninth urotergite : 0.40 mm.; length of projecting part of ovipositor : 3.8 mm.; length of fore wing : 1.5 mm.; width of fore wing : 0. 60 mm.; length of hind wing : 1.0 mm.; width of hind wing : 0.25 mm.

Male, Form 1.—Head transparent brownish-yellow; thorax yellowish-brown; abdomen pale yellowish-brown; mandibles and antennal scape reddish-brown; rest of antenna yellowish; legs brownish-yellow; eyes black; wings hyaline.

The dorsal side of the head and of the pronotum much apart and provided with short setae; the ventral side of the head and of the thorax with moderately long setae; legs densely clothed with long thick setae; the sides and hinder margin of head with many short setae; abdomen with sparse long setae.

Head (Fig. IV, 35). Subrectangular, one and one-fifth as long as its maximum width; anterior and posterior angles not strongly rounded; epistomal margin emarginate in the middle and as in figure; lateral margins of head faintly converging forwards; posterior margin weakly concave; frontal region posterior to the anterior depression inclined, with a series of semicircular and irregular rugosities; eyes small. Antenna (Fig. IV, 36) with eleven segments; scape thrice as long as its maximum thickness, with setae as in figure; second segment twice as long as thick; third reduced and ring-like; fourth as long as thick; fifth a little longer than thick; sixth a little longer than the fifth but a trifle less thick; seventh as long as sixth but slightly thicker; eighth longer and thicker than seventh; ninth, tenth and eleventh segments fused to form a club of length a little less than two and a half times its maximum thickness; segments five to eleven with sensoria as in figure. Mandible (Fig. IV, 37) large and stout, one and five-sixths as long as wide, tridentate, teeth and setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. IV, 38). Pronotum distinctly wider than long and wider than the head, its dorsal side with short setae; lateral margins converging forwards. Rest of thorax and propodeum a little over one and a half times as wide as its median length; propodeal spiracles with small rounded peritremes situated as in figure. Fore wing a little over one and one-third as long as the hind wing. Fore leg (Fig. IV, 39): Coxa over one and a half times as long as wide, obliquely weakly rugose, with thick setae as in figure; trochanter one and two-thirds as long as wide, setae as in figure; femur about two and three-fourths as long as its maximum width, longer than the coxa, obliquely weakly rugose, with long setae as in figure; tibia two and one-fourth as long as its maximum width, shorter than the femur, with long setae, odontoid spines and a bifid spur as in figure. Tarsi less than half as long as the tibia; fifth segment three-fourths the entire tarsal length and twice as long as its own maximum width. Mid leg (Fig. IV, 40) : Coxa a little less than one and a half times as long as wide, obliquely weakly rugose, with long setae as in figure; trochanter long, about two and a half times as long as wide, with long setae as in figure; tibia longer than the femur, thrice as long as wide, with long setae, odontoid spines and tibial spur as in figure. Tarsi a little longer than half the tibia; fifth segment two-thirds the entire tarsal length. Hind leg (Fig. IV, 41) : Coxa a little less than two and a half times as long as wide, obliquely rugose, with long setae as in figure; trochanter twice as long as wide, setae as in figure; femur two and a half times as long as wide, with many long setae as in figure; tibia longer than the femur, a little less than two

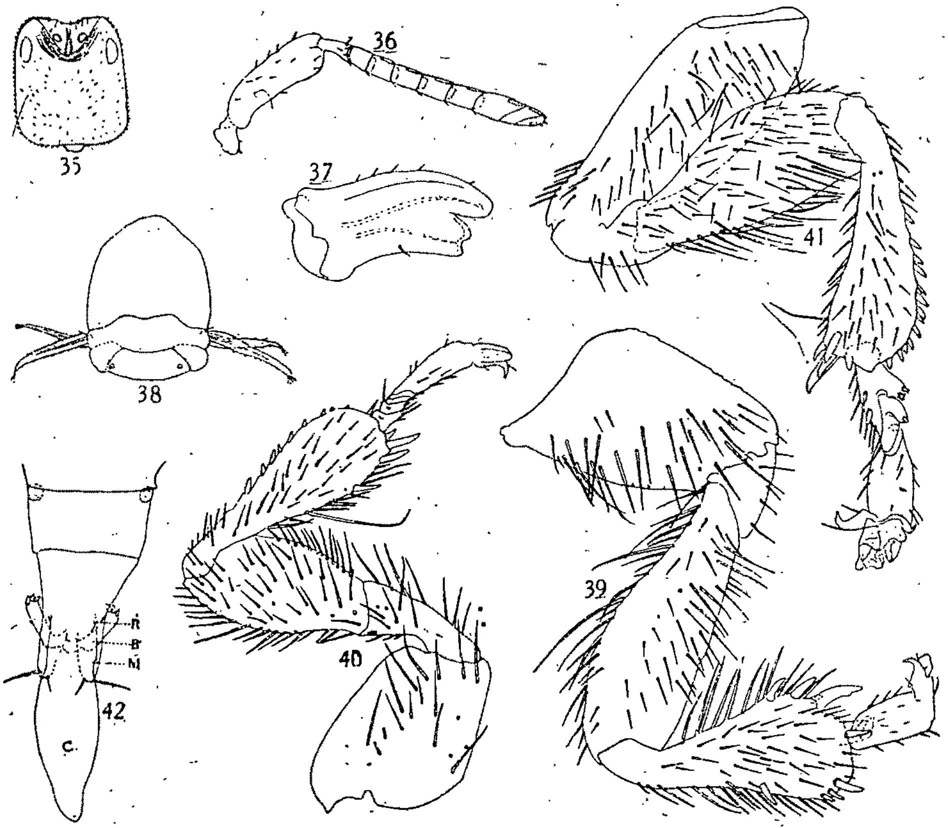


Fig. IV.—*Philotrypesis pilosa* Mayr. Male, Form 1 : 35, head; 36, antenna; 37, mandible; 38, thorax and propodeum; 39, fore leg; 40 mid leg; 41, hind leg; 42, dorsal view of eighth and ninth urites, genital armature and penis : lettering as in fig. II.

and a half times as long as wide, with setae, odontoid spines and spurs as in figure. Tarsi two-thirds the tibia; metatarsus about half as long as the tarsi and twice as long as its own maximum width, with two long macrochetae, setae and odontoid spines as in figure; the second segment with a single long macrocheta on its dorsal margin; fifth segment hardly a little longer than the metatarsus and a little over twice as long as wide.

Abdomen twice as long as wide; the urotergites with a row of long setae near their distal margin; the eighth urotergite with a pair of spiracles with small rounded peritremes situated laterally; ninth with two small pseudocerci (Fig. IV, 42, R) each furnished with one seta; genital armature with two distal, ventral and flattened processes (Fig. IV, 42, M) each with two long setae, and two dorsal, depressed, long and distally dilated appendages (Fig. IV, 42, B), each with three short, stout odontoid spines; penis as in figure IV, 42, C.

Male, Form 2.—Head transparent brownish-yellow; thorax and abdomen yellowish-brown; mandibles and antennal scape reddish-brown; rest of antenna pale yellow; legs yellowish-brown except for the tibiae which are somewhat pale reddish-brown; eyes black; wings hyaline.

Head (Fig. V, 43). Subrectangular, with the anterior and posterior angles not strongly rounded, a little less than one and one-fourth as long as wide; epistomal margin emarginate in the middle and as in figure; lateral margins of head weakly converging forwards and with many short setae; posterior margin weakly concave, with short setae; frontal region posterior to the anterior depression inclined, with a series of semicircular and irregular rugosities; ventral side of head with a clothing of setae; eyes small. Antenna (Fig. V, 44) with eleven segments; scape thrice as long as thick, with setae as in figure; second segment one and two-thirds as long as thick; third reduced and ring-like; fourth a little less than one and one-fourth as long as thick; fifth a little thicker than long; sixth as long as thick, a little longer than the preceding segment, seventh a little longer than sixth, longer than thick; eighth longer and thicker than seventh, longer than thick; ninth, tenth and eleventh segments fused to form a club of length twice its thickness;

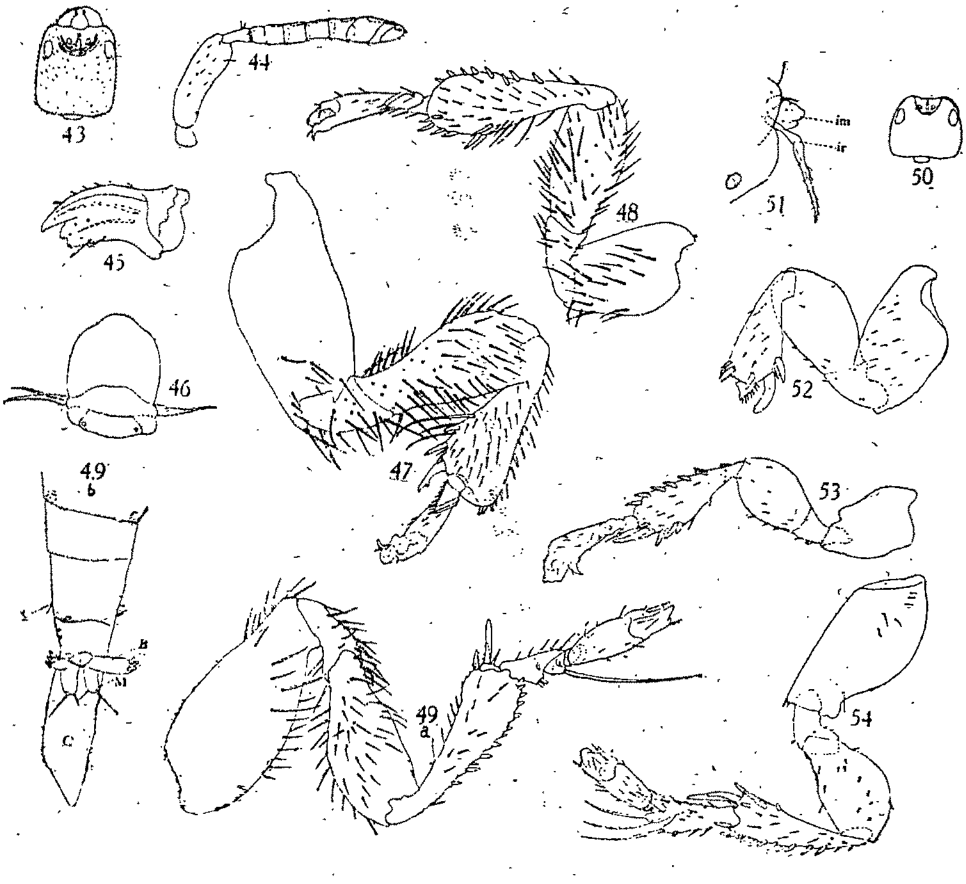


FIG. V.—*Philotrypesis pilosa* Mayr. Male, Form 2 : 43, head; 44, antenna; 45, Mandible; 46, thorax and propodeum; 47, fore leg; 48, mid leg; 49a, hind leg; 49b, dorsal view of eighth and ninth urites, genital armature and penis : lettering as in fig. II. *Philotrypesis quadrisetosa* (Westwood). Male, Form 2: 50, head; 51, fore and hind wings, in situ; 52, fore leg; 53 mid leg; 54, hind leg; im, reduced fore wing; ir, hind wing.

segments five to eleven with sensoria as in figure. Mandible (Fig. V, 45). Length a little less than twice its maximum width, tridentate, teeth and setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. V, 46). Pronotum wider than long, wider than the head; its lateral margins converging forwards, with short setae. Length of rest of thorax and propodeum a little over two-thirds its width. Fore wing one and one-fourth as long as the hind wing. Fore leg (Fig. V, 47) : Coxa twice as long as wide, its outer face with numerous long setae, obliquely weakly rugose; trochanter about twice as long as wide, with long setae as in figure; femur two and a half times as long as wide, shorter than the coxa, with a clothing of long setae as in figure; tibia a little shorter than the femur, about two and a half times as long as its maximum width, with setae, odontoid spines and a bifid spur as in figure; tarsi half as long as the tibia. Mid leg (Fig. V, 48) : Coxa a little less than one and a half times as long as wide, obliquely weakly rugose, with long setae as in figure; trochanter a little over twice as long as wide, setae as in figure; femur a little less than twice as long as wide, with a clothing of long setae as in figure; tibia long, a little over thrice as long as wide, with setae, odontoid spines and spur as in figure. Tarsi distinctly longer than half the tibia; fifth segment five-eighths the entire tarsal length. Hind leg (Fig. V, 49) : Coxa a little less than two and a half times as long as wide, obliquely weakly rugose, its inner face with setae as in figure, outer face with numerous long setae; trochanter a little over twice as long as wide, with setae as in figure; femur about two and one-fourth as long as wide, with a clothing of long setae as in figure; tibia distinctly longer than the femur, about three and a half times as long as wide, with setae, odontoid spines and spurs as in figure. Tarsi two-thirds the tibia; metatarsus about half the tarsal length, two and one-third as long as its own width, with two long macrochetae on its dorsal margin; second segment with one macrocheta on its dorsal margin; fifth segment equal to the metatarsus.

Abdomen. Length twice its width; the urotergites with a few setae each; eighth urotergite with a pair of spiracles with small rounded peritremes situated laterally; ninth with a pair of pseudocerci (Fig. V, 49b, R), each with one seta; genital armature with two distal, ventral, flattened processes (Fig. V, 49b, M), each with two long setae, and two dorsal, depressed, long and distally dilated appendages (Fig. V, 49b, B), each with three short, stout odontoid spines; penis as in figure V, 49b, C.

MEASUREMENTS

	Male, Form 1.	Male, Form 2.
Length of body	2·3 mm.	1·8 mm.
Length of head	0·64 mm.	0·47 mm.
Width of head	0·55 mm.	0·37 mm.
Length of pronotum	0·47 mm.	0·36 mm.
Width of pronotum	0·60 mm.	0·44 mm.
Length of rest of thorax and propodeum	0·36 mm.	0·27 mm.
Width of mesonotum	0·58 mm.	0·42 mm.
Length of abdomen	0·95 mm.	0·75 mm.
Width of abdomen	0·47 mm.	0·36 mm.
Length of fore wing	0·49 mm.	0·36 mm.
Length of hind wing	0·38 mm.	0·29 mm.

Geographical distribution. Collected by K. J. Joseph from the figs of *Ficus hispida* Linn. from Nagambadam, Kottayam, Travancore, dated 2nd June, 1953, and from the same host from Forest Research Institute Estate, New Forest, Dehra Dun, dated 25th June, 1953.

Philotrypesis longispinosa, sp. nov.

Head, thorax and abdomen yellowish-brown; apical half of mandibles and the hinder region of the scutellum somewhat brownish-red; antennal segments six to thirteen and the ovipositor-valves smoky-brown; wings hyaline; nervures amber; pubescence pale brownish-black; abdomen above each tergite with a dark brownish-black transverse band, those on the fourth and fifth urotergites large; tail-like part of abdomen above with a median longitudinal dark brownish-black band; eyes coralline; ocelli pale pinkish-white.

Head (Fig. VI, 55) distinctly wider between the external margins of the eyes than long; epistomal margin emarginate as in figure; lateral margin of head forwards of eyes half the longitudinal diameter of the eye, and converging forwards; posterior margin of head behind the eyes broadly rounded; eyes large; ocelli three as in figure; an imaginary line connecting the anterior ends of the two eyes divides the antennal toruli into an anterior two-thirds and a posterior one-third; dorsum of head rugose, more so posteriorly. Antenna (Fig. VI, 56) with thirteen segments, of which three form ring-joints; scape about six times as long as its maximum thickness, much longer than the five following segments combined, with setae as in figure; second segment a little less than twice as long as thick; third, fourth and fifth form ring-joints, each with a whorl of setae and increasing in size from the third to the fifth; sixth twice as long as thick; seventh a little longer and thicker than the sixth; eighth a little longer than seventh, twice as long as thick; ninth as long as seventh but a little less thick; tenth a little shorter than sixth but slightly thicker; eleventh, twelfth and thirteenth segments form a club three and a half times as long as its maximum thickness, the segments decreasing in length from the eleventh to the thirteenth; segments six to thirteen with long and slender, and short and stout sensoria and with long setae as in figure. Mandible about one and one-third as long as wide, bidentate. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. VI, 57). Pronotum with its lateral margins a little diverging posteriorly, transversely and obliquely weakly

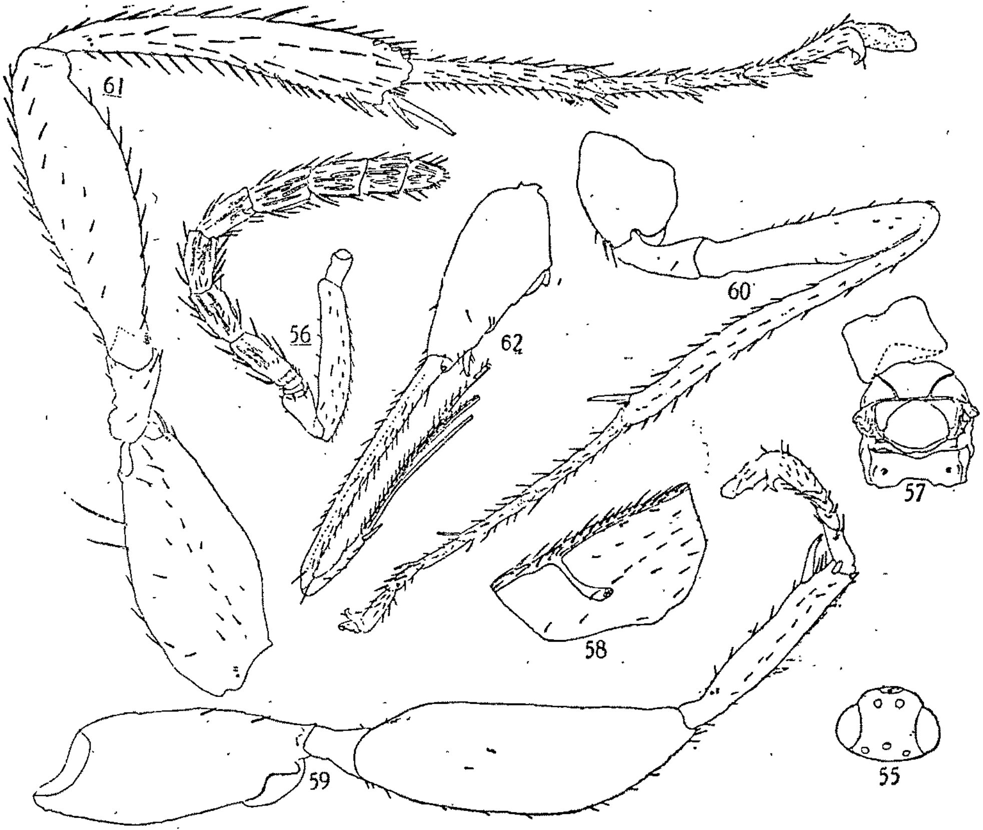


FIG. VI.—*Philotrypesis longispinosa*, sp. nov. Female : 55, head; 56, antenna; 57, thorax and propodeum, 58, details of stigmal vein; 59, fore leg; 60, mid leg; 61, hind leg; 62, abdomen.

rugulose. Mesonotum with the scutum about twice as wide as long, transversely rugulose, with a few minute setae; scapula a little wider than long, transversely rugulose, with a few small setae; scutellum wider than long, flat; axilla as long as wide. Length of thorax and propodeum a little over one and one-third its maximum width. Fore wing two and a half times as long as its maximum breadth; distal extremity rounded; costal cell about ten times as long as broad; submarginal vein one and one-fourth as long as the marginal; marginal about one and a half times as long as the postmarginal; postmarginal thrice as long as the stigmal; stigmal vein as in fig. VI, 58, with four rounded sensillae at its distal end. Pubescence sparse, those in the anterior half longer than those posterior; marginal fringe short. Hind wing about four times as long as its maximum breadth, with three frenal hooks; pubescence short except for a row of long pila along the anterior margin; marginal fringe mediocre-sized. Fore leg (Fig. VI, 59): Coxa a little over twice as long as its maximum width, transversely rugose; trochanter one and one-fourth as long as wide; femur large, a little less than two and a half times as long as its maximum width, longitudinally weakly rugose; tibia six times as long as wide, longitudinally and obliquely weakly rugose, with setae, spines, odontoid spines and spur as in figure. Tarsi a little less than two-thirds the tibia; metatarsus a little longer than the two following segments combined; fifth hardly a little longer than the metatarsus. Mid leg (Fig. VI, 60) : Coxa a little wider than long, transversely weakly rugose; trochanter a little over twice as long as wide; femur about five and a half times as long as its maximum width, transversely and obliquely rugose, with setae as in figure; tibia long, length thirteen times width, longer than the femur and trochanter considered together, with setae and apical spur as in figure. Tarsi a little shorter than the tibia; metatarsus equal to the two following segments combined. Hind leg (Fig. VI, 61): Coxa a little over two and one-fourth as long as its maximum width, obliquely rugose, with about five macrochetae on its outer face, inner face as in figure; trochanter a little over twice as long as wide, with sensillae and setae as in figure; femur three and a half times as long as its maximum width, obliquely and transversely rugose, setae and sensillae as in figure; tibia a little longer than the femur, five and three-fourths as long as wide, obliquely rugose, with setae, sensillae, spines and spurs as in figure. Tarsi much longer than the tibia; metatarsus a little longer than the two following segments combined. Propodeum (Fig. VI, 57) a little less than thrice as wide as its maximum length, transversely and obliquely weakly rugose, with setae and a pair of spiracles with small rounded peritremes as in figure.

Abdomen (Fig. VI, 62). Length of abdomen upto the seventh tergite a little less than twice its height; seventh urotergite with a few setae, eighth and ninth with numerous long setae; tail-like part of abdomen a little less than twice the length of the abdomen upto the seventh tergite; eighth urotergite about one and a half times as long as the abdomen upto the seventh tergite; ninth a little less than one-third the eighth; ovipositor very long, its projecting part one and two-thirds as long as the length of urotergites two to nine; ovipositor-valves setiferous.

Measurements. Length of body : 3.8 mm.; length of head : 0.38 mm.; width of head : 0.49 mm.; length of thorax and propodeum : 0.79 mm.; width of mesonotum: 0.57 mm.; length of urotergites three to seven : 0.92 mm.; length of eighth urotergite : 1.3 mm.; length of ninth urotergite : 0. 42 mm.; length of fore wing: 1.5 mm.; breadth of fore wing : 0.62 mm.; length of hind wing : 1.14 mm.; breadth of hind wing : 0.29 mm.

Male.—Head pale reddish-brown; thorax and abdomen yellowish-brown; mandibles reddish-brown; trochanter, femur and tibia of fore leg and parts of coxa, trochanter and tibia of hind leg rusty red-brown; antennal scape pale reddish-brown, rest of antenna pale yellow; eyes black.

Head (Fig. VII, 63) wider than long; epistomal margin as in figure; lateral margins gently converging forwards, with a few setae; posterior margin of head a little concave; anterior angles of head obtuse but not rounded; the frontal region posterior to the anterior depression with semicircular rugosities; the posterior extremity of the head transversely rugulose; dorsum of head with numerous long macrochetae and small setae as in figure; ventral side of head, especially the sublateral regions with a clothing of setae. Eyes small. Antenna (Fig. VII, 64) with eleven segments; scape three and one-third as long as thick, with setae as in figure;

segment two long and slender, about two and a half times as long as thick, with a few setae distally; third segment small but longer than in most of the other species of the genus, distinctly thicker than long; fourth, fifth and sixth clearly longer than thick, equal in length and increasing in thickness from the fourth to the sixth; seventh and eighth equal, as long as thick; ninth, tenth and eleventh segments fused to form a club a little less than two and a half times as long as its maximum thickness; segments five to eleven with long setae and sensoria as in figure. Mandible (Fig. VII, 65) long, two and two-sevenths as long as wide, tridentate, teeth and setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. IX, 88). Pronotum one and one-third as wide as long; lateral margins converging posteriorly; anterior margin

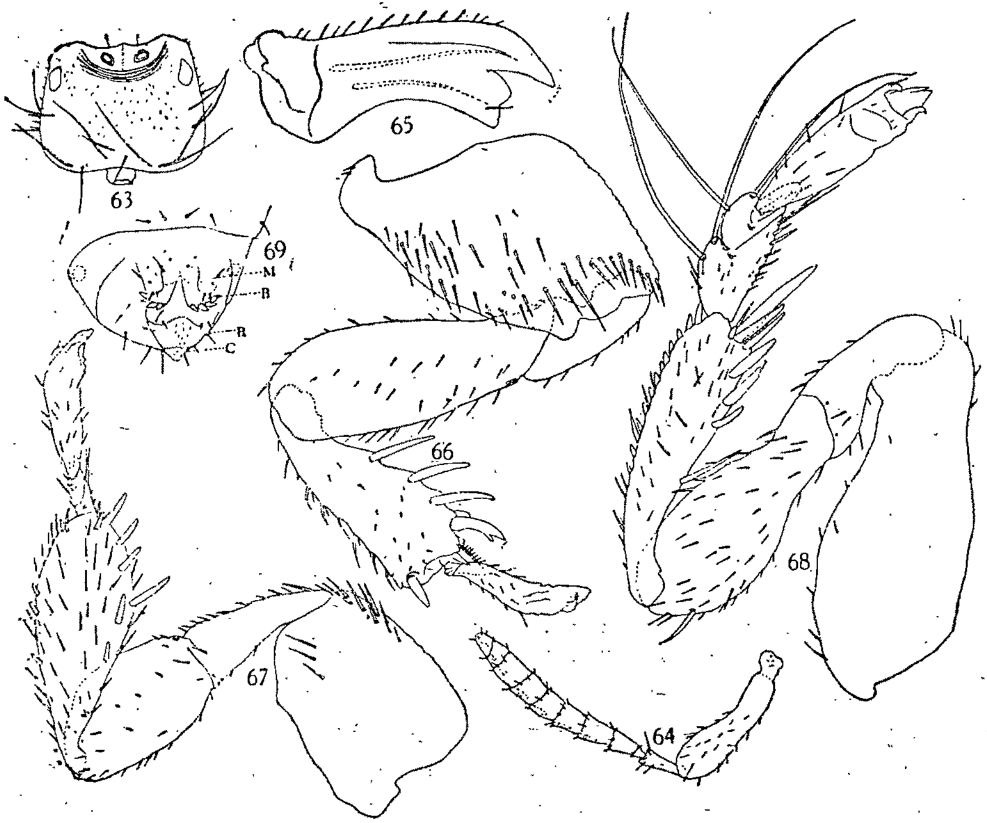


FIG. VII.—*Philotrypesis longispinosa*, sp. nov. Male : 63, head; 64, antenna; 65, mandible; 66, fore leg; 67, mid leg; 68, hind leg; 69, ventral view of eighth and ninth urites, genital armature and penis ; lettering as in fig. II

as in figure. The pronotum bears about twelve macrochetae and a few minute setae disposed as in figure. Rest of thorax and propodeum one and five-sevenths as wide as its median length; the mesonotum with about fifteen macrochetae and many small setae as in figure; metanoto-propodeum with about six macrochetae as in figure; propodeum with a pair of spiracles with small rounded peritremes. Wings (Fig. IX, 89) long and slender; fore wing (im) one and one-fourth as long as the hind wing(ir). Fore leg (Fig. VII, 66) : Coxa large, one and two-fifths as long as wide, obliquely weakly rugose, with stout setae and sensillae as in figure; trochanter less than twice as long as wide; femur hardly a trifle longer than or equal to the coxa, length about two and a half times its maximum width, longitudinally weakly rugose, with short setae; tibia a little longer than five-sixths the femur, with setae, spines, long odontoid spines and a bifid spur as in figure. Length of tarsi less than half the tibia; fifth segment about three-fourths the entire tarsal length. Mid leg (Fig. VII, 67) : Coxa a little over one and a half times as long as wide, obliquely weakly rugose, with setae as in figure; trochanter about thrice as long as wide, with a few setae and sensillae; femur a little longer than one and a half times its width, longitudinally weakly rugose, with a few short setae; tibia one and a half times as long as the femur, a little over two and two-thirds as long as its maximum width, claviform, with setae, odontoid spines, sensillae and tibial spur as in figure. Tarsi three-fifths the tibia; fifth segment two-thirds the entire tarsal length. Hind leg (Fig. VII, 68) : Coxa very long, a little over two and a half times as long as wide, obliquely rugose; trochanter about two and a half times as long as wide; length of femur a little less than two and a half times its width, with long spines and setae as in figure; tibia distinctly longer than the femur, about four times as long as wide, with setae, spines, odontoid spines and tibial spurs as in figure. Tarsi a little longer than three-fourths the tibia; metatarsus equal to half the entire tarsal length and twice as long as wide, its dorsal projecting margin with two extremely long macrochetae; second segment a little longer than half the metatarsus, with two long macrochetae on its dorsal projecting margin; length of fifth segment equal to the metatarsus, over twice as long as wide.

Abdomen with a somewhat dense clothing of long and short setae dorsally, ventral side with a few short setae; eighth urotergite with a pair of spiracles with small rounded peritremes situated laterally; ninth with a pair of small pseudocerci (Fig. VII, 69, R), each with one long seta; genital armature with a pair of ventral, flattened processes (Fig. VII, 69, M) each with two setae, and two dorsal, depressed, long and distally dilated processes (Fig. VII, 69, B), each with four short, stout odontoid spines; penis not exserted and as in figure VII, 69, C.

Measurements. Length of body : 2.4 mm.; length of head : 0.69 mm.; width of head : 0.79 mm.; length of pronotum : 0.57 mm.; width of pronotum : 0.75 mm.; length of rest of thorax and propodeum : 0.38 mm.; width of mesonotum : 0.68 mm.; length of fore wing : 0.46 mm.; length of hind wing : 0.36 mm.; length of abdomen : 0.80 mm.; width of abdomen : 0.44 mm.

Holotype 1 female dissected on slides Nos. 23/7-1 and 23/7-2; *allotype* 1 male dissected on slides Nos. 23/19-1, 23/19-2 and 23/19-3.

Geographical distribution. Collected by K. J. Joseph from the figs of *Ficus mysorensis* Hayne from Thalakvady, Belgaum, dated 17th June, 1953.

Philotrypesis palmata, sp. nov.

Female.—Head, thorax and abdomen of a fundamentally yellowish-brown colour; mandibles and the dorsum of the fourth and fifth urotergites somewhat brownish-red; antennal segments three to thirteen and the hinder part of the scutellum smoky-brown; eyes coralline; wings hyaline, nervures amber; the abdomen above each segment with a brownish-black band; tail-like part of the abdomen brownish-black above; ovipositor-valves dark sooty-brown.

Head (Fig. VIII, 70) wider between the external margins of the eyes than long; epistomal margin as in figure; lateral margin forwards of eye a little less than two-thirds the longitudinal diameter of the eye and converging forwards; posterior margin of head behind the eyes broadly rounded; eyes and ocelli as in figure; dorsum of head very faintly rugulose, more so posteriorly; the posterior limit of the antennal toruli just touch an imaginary line connecting the anterior ends of the two eyes. Antenna (Fig. VIII, 71) with thirteen segments, of which three form ring-joints; scape five times as long as its maximum thickness, and longer than the five following segments combined,with setae as in figure; second segment less than twice as long as its thickness, equal to the scape in thickness; third , fourth and fifth form ring-joints which increase in size from the third to the fifth; sixth one and a half times as long as thick; seventh a little longer and thicker than the sixth; eighth equal to the sixth; ninth equal to the seventh; tenth short, a little longer than thick; eleventh, twelfth and thirteenth form a club of length two and a half times its maximum thickness; segments six to thirteen with short and stout sensoria and long setae as in figure. Mandible (Fig. VIII, 72) about one and a half times as

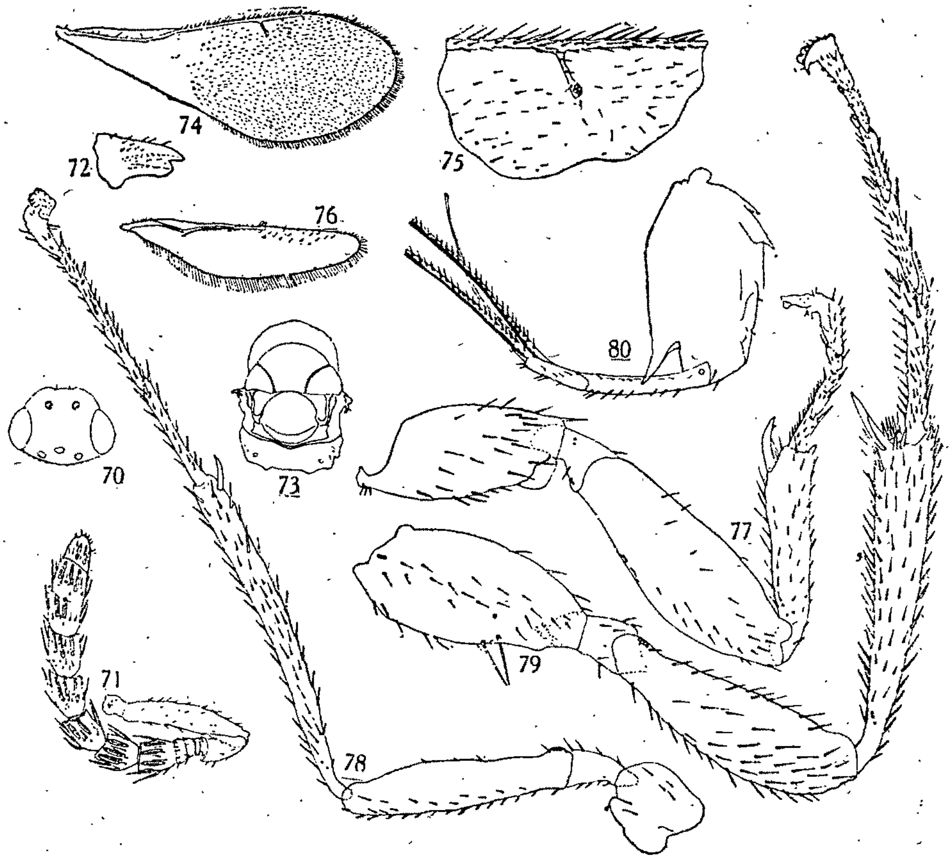


FIG. VIII.—*Philotrypesis palmata*, sp. nov. Female : 70, head; 71, antenna; 72, mandible; 73, thorax and propodeum; 74, fore wing; 75, details of stigmal vein; 76, hind wing; 77, fore leg; 78, mid leg; 79, hind leg; 80, abdomen.

long as wide, bidentate, teeth and setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. VIII, 73). Pronotum with its lateral margins a little diverging posteriorly, transversely rugulose. Mesonotum with the scutum about one and a half times as wide as long, transversely rugulose, with a few small setae; scapula a little wider than long, transversely rugulose; scutellum wider than long, reticulately weakly rugulose; axilla as long as wide, with a few microscopic setae in its hinder angle. Length of thorax and propodeum one and a half times as long as its maximum width. Fore wing (Fig. VIII, 74) about two and a half times as long as its maximum breadth; distal extremity rounded; costal cell about ten times as long as its breadth; submarginal vein one and one-sixth as long as the marginal; marginal about two and two-thirds as long as the postmarginal; postmarginal a little longer than twice the stigmal; stigmal vein as in figure VIII, 75, with four small rounded sensillae at its distal extremity; alar pubescence of medium size in the anterior half, short in the posterior half; marginal fringe of mediocre size. Hind wing (Fig. VIII,76) about four times as long as its maximum breadth, with three frenal hooks; pubescence in the anterior margin longer than those posterior; marginal fringe moderately long. Fore leg (Fig. VIII, 77) : Coxa a little over twice as long as wide, transversely and obliquely rugulose with setae as in figure; trochanter one and a half times as long as its maximum width, sensillae and setae as in figure; femur two and two-thirds as long as wide, as long as the coxa and trochanter taken together, with setae as in figure; tibia equal in length to the coxa, about five and a half times as long as its maximum width, with setae, spines and a long bifid spur as in figure. Tarsi three-fourths the tibia; metatarsus equal to the two following segments combined. Mid leg (Fig. VIII, 78) : Coxa a little longer than wide, obliquely and transversely rugulose; trochanter twice as long as wide, with sensillae and setae as in figure; femur a little less than five times as long as its maximum width, transversely and obliquely rugulose, with setae and sensillae as in figure; tibia long, longer than the femur and trochanter considered together, about ten times as long as wide, with setae, spines and spur as in figure. Tarsi distinctly shorter than the tibia; metatarsus shorter than the two following segments combined. Hind leg (Fig. VIII, 79) : Coxa about two and a half times as long as its maximum width, transversely and obliquely rugose, its outer face with about five macrochetae, inner face with setae as in figure; trochanter a little over twice as long as wide; femur three and a half times as long as its maximum width, obliquely rugose, with about six specialized setae on its outer face, and sensillae and setae on its inner face as in figure; tibia distinctly longer than the femur, a little less than six times as long as its maximum distal width, obliquely weakly rugulose, with sensillae, setae, odontoid spines and spurs as in figure. Tarsi distinctly longer than the tibia; metatarsus much shorter than the two following segments combined. Propodeum a little over thrice as wide as its maximum length, transversely and obliquely rugulose, with setae and a pair of spiracles with small rounded peritremes as in figure.

Abdomen (Fig. VIII, 80). Length of abdomen upto the seventh tergite one and four-fifths the height of the abdomen; sixth and seventh urotergites with a few long setae; tail-like part of the abdomen about one and one-third as long as the abdomen upto the seventh tergite; eighth urite shorter than the abdomen upto the seventh tergite; ninth a little over half the eighth; eighth and ninth urotergites with setae as in figure; projecting part of ovipositor comparatively short, much longer than the length of the urites two to nine; ovipositor and valves as in figure.

Measurements. Length of body : 2.9 mm.; length of head : 0.40 mm.; width of head : 0.49 mm.; length of thorax and propodeum : 0.77 mm.; width of mesonotum : 0.51 mm.; length of abdomen upto the seventh tergite : 0.80 mm.; length of eighth urotergite : 0.66 mm.; length of ninth urotergite : 0.36 mm.; length of projecting part of ovipositor : 2.5 mm.; length of fore wing : 1.58 mm.; breadth of forewing : 0.64 mm.; length of hind wing : 1.14 mm.; breadth of hind wing : 0.27 mm.

Male, Form 1.—Head rusty yellow-brown; pronotum yellowish-brown, rest of thorax and abdomen pale yellowish-brown; legs with a fundamental pale yellowish-brown colour, the trochanter, femur and tibia of the fore leg and the trochanter and proximal part of the tibia of the hind leg rusty yellow-brown; mandibles reddish-brown; antennae yellowish-white except for the scape which is yellowish-brown; eyes black.

Head (Fig. IX, 81) a little wider than long; epistomal margin as in figure; lateral margins of head converging forwards; posterior margin of head weakly concave; posterior angles of head obtuse and rounded; the frontal region posterior to the anterior depression with semicircular rugosities; dorsum of head with many long macrochetae (some of which have fallen off, leaving their scars only) and small setae. Antenna (Fig. IX, 82) with eleven segments; length of scape about three and one-fourth its thickness, with setae as in figure; second segment twice as long as thick; third

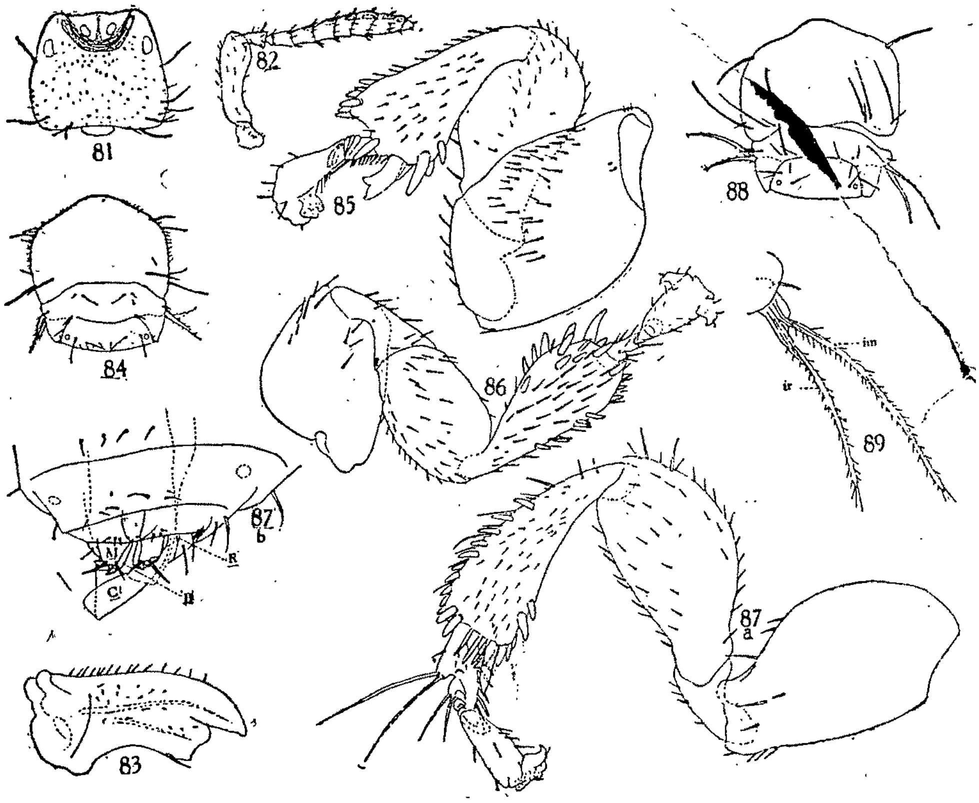


FIG. IX.—*Philotrypesis palmata*, sp. nov Male, Form 1 : 81, head; 82, antenna; 83, mandible; 84, thorax and propodeum; 85, fore leg; 86, mid leg; 87a, hind leg; 87b, ventral view of eighth and ninth urites, genital armature and penis. *Philotrypesis longispinosa*, sp. nov. Male : 88, thorax and propodeum; 89, fore and hind wings in situ, magnified. Lettering as in fig. V.

small, one and a half times as thick as long; fourth longer than thick and as in figure; fifth a little shorter than fourth but thicker than it; sixth as long as fifth, length equal to its thickness; seventh a little longer than the preceding segment, length equal to its thickness; eighth a little longer than the seventh, as long as thick; ninth, tenth and eleventh segments fused to form a club of length twice its maximum thickness; segments five to eleven with setae and short and stout sensoria as in figure. Mandible (Fig. IX, 83) long , a little less than twice as long as wide, tridentate, teeth and setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. IX, 84). Pronotum hardly a trifle wider than the head, about one and one-third as wide as long, its anterior margin convex and as in figure; lateral margins slightly converging posteriorly. The pronotum bears over a dozen macrochetae and many small setae as in figure. Rest of thorax and propodeum one and three-fifths as wide as its median length; mesonotum with about eight macrochetae disposed as in figure; metanoto-propodeum with about ten macrochetae as in figure; propodeal tracheal spiracles with small rounded peritremes. Fore wing one and one-third as long as the hind wing. Fore leg (Fig. IX, 85) : Coxa stout, one and one-fourth as long as wide, obliquely weakly rugose, with setae as in figure; trochanter about one and three-fourths as long as wide; femur as long as coxa, less than twice as long as wide, faintly rugulose, with setae as in figure; tibia shorter than femur, twice as long as its maximum width, with setae, odontoid spines and a bifid spur as in figure; tarsi three-fifths the tibia, fifth segment two-thirds the entire tarsal length. Mid leg (Fig. IX, 86) : Coxa one and a half times as long as wide, obliquely weakly rugose, with a few setae; trochanter hardly twice as long as wide; femur a little over one and a half times as long as wide, transversely and obliquely weakly rugose, with setae as in figure; tibia distinctly longer than the femur, two and three-fifths as long as its maximum width, claviform, with setae, odontoid spines and spur as in figure. Tarsi clearly longer than half the tibia; fifth segment a little over half the tarsal length. Hind leg (Fig. IX, 87a) : Coxa a little less than twice as long as wide, obliquely rugose, with three macrochetae on its outer face situated as in figure; length of trochanter a little than twice its width; length of femur a little less than twice its width, transversely and obliquely weakly rugose, with setae as in figure; tibia longer than femur, longer than twice its own width, with setae, odontoid spines and spurs as in figure. Tarsi distinctly shorter than the femur; metatarsus a little longer than half the tarsal length, about two and a half times as long as its maximum width, its ventral margin with long, stout spines, its dorsal margin at its projecting apex with two very long macrochetae; second segment small, less developed than in other species, its dorsal margin at its projecting apex with two smaller macrochetae; fifth segment a little shorter than the metatarsus.

Abdomen. Length a little over one and a half times its width; the urotergites with a row of long setae; eighth with a pair of spiracles with small rounded peritremes; ninth with a pair of small pseudocerci (Fig. IX, 87b, R), each bearing a long seta; genital armature with a pair of ventral, flattened processes (Fig. IX, 87b, M), each with two long setae apically, and a pair of dorsal, long, depressed, distally dilated appendages (Fig. IX, 87b,B), each with three short, stout odontoid spines; penis as in figure IX, 87b, C.

Male, Form 2. *Colour* slightly paler than in Form 1. *Head* (Fig. X, 90) as long as wide; epistomal margin as in figure; lateral margins converging forwards; posterior margin of head weakly concave; the frontal region posterior to the anterior depression with semicircular rugosities; dorsum of head with many small setae and with macrochetae as in figure; eyes small. Antenna (Fig. X, 91) with eleven segments; scape three and a half times as long as thick, with setae as in figure; second segment twice as long as thick, with long setae; third small, one and a half times as thick as long; fourth and fifth segments equal, a little longer than thick; sixth slightly thicker than long; seventh as long as sixth but thicker than it; ninth, tenth and eleventh segments fused to form a club of length two and one-third times its maximum thickness; segments five to eleven with sensoria and setae as in figure. Mandible (Fig. X, 92) long, a little less than twice as long as wide, tridentate, teeth and setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. X, 93). Pronotum a little wider than the head, about one and one-fourth as wide as its own median length; anterior margin as in figure; lateral margins weakly converging posteriorly; posterior margin concave. The pronotum bears about a dozen macrochetae disposed as in figure. Rest of thorax and propodeum about one and two-thirds as wide as its median

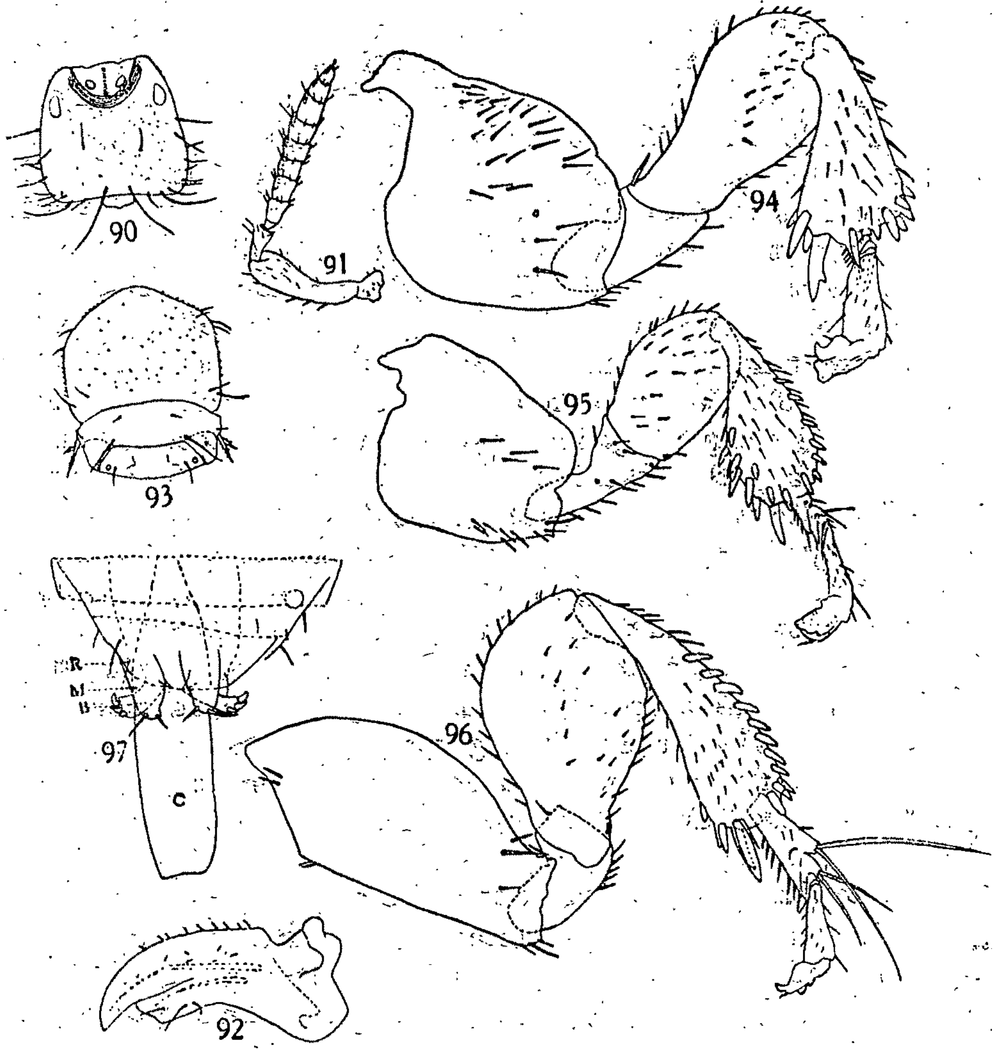


FIG. X.—*Philotrypesis palmata*, sp. nov. Male, Form 2 : 90, head; 91, antenna; 92, mandible; 93, thorax and propodeum; 94, fore leg; 95, mid leg; 96, hind leg; 97, ventral view of eighth and ninth urites, genital armature and penis; lettering as in fig. II.

length; mesonotum with six macrochetae, of which the two posterior ones are very long; propodeum with about six macrochetae and spiracles with small rounded peritremes as in figure. Wings short, fore wing a little longer than the hind wing. Fore leg (Fig. X, 94) : Coxa about one and one-third as long as wide, obliquely weakly rugose, with setae as in figure; trochanter a little less than one and three-fourths as long as wide; femur a little less than twice as long as thick, shorter than coxa, weakly rugulose, with setae as in figure; tibia shorter than femur, twice as long as wide, with setae, odontoid spines and a bifid spur as in figure. Tarsi three-fifths tibia; fifth segment about two-thirds the tarsal length. Mid leg (Fig. X, 95) : Coxa about one and one-third as long as wide, obliquely weakly rugose; trochanter a little less than twice as long as wide, with setae and sensillae as in figure; femur about one and a half times as long as wide, obliquely weakly rugose, with setae as in figure; tibia claviform, a little less than twice as long as wide, distinctly longer than the femur, with setae, odontoid spines and spur as in figure. Tarsi a little over two-thirds the tibia; fifth segment three-fifths the tarsal length. Hind leg (Fig. X, 96): Coxa two and one-sixth as long as wide, with transverse and oblique rugosities and with three macrochetae on its outer distal part, of which one is longer than the rest; trochanter about twice as long as wide; femur less than twice as long as wide, obliquely weakly rugose, with setae as in figure; tibia as long as the femur, thrice as long as its own maximum width, with setae, odontoid spines and spurs as in figure. Tarsi three-fourths the tibia; metatarsus a little over half the tarsal length, more than twice as long as its own maximum width, with two very long macrochetae on its dorsal projecting margin; second segment small with two shorter macrochetae on its dorsal projecting margin; fifth segment four-fifths the metatarsus.

Abdomen about one and one-third as long as wide; the urotergites with a row of long setae; eighth with a pair of spiracles with small rounded peritremes situated laterally; ninth with a pair of small pseudocerci (Fig. X, 97, R) each with a seta; genital armature with a pair of ventral, flattened processes (Fig. X, 97, M), each with two setae distally, and a pair of dorsal, long, depressed, distally dilated appendages (Fig. X, 97, B), each bearing three short, stout odontoid spines; penis as in figure X, 97, C.

Male, Form 3. *Colour*: Slightly paler than Form 2. *Head* (Fig. XII, 120) a little longer than wide; epistomal margin as in figure; lateral margins converging forwards; posterior margin weakly concave; anterior and posterior angles rounded; the frontal region posterior to the anterior depression with semicircular rugosities; dorsum of head with about a dozen macrochetae and a few short setae; eyes small. Mandible a little longer than one and two-thirds its maximum width, tridentate.

Thorax (Fig. XII, 121). Pronotum wider than long, as wide as the head; anterior margin as in figure; lateral margins converging posteriorly. The pronotum bears a few macrochetae and setae as in figure. Rest of thorax and propodeum a little over one and a half times as wide as long; mesonotum with two pairs of setae; metanoto-propodeum with four pairs of macrochetae disposed as in figure. Fore and hind wings small and reduced, fore wing a little longer than the hind wing. Fore leg (Fig. XII, 122) : Coxa one and one-third as long as wide, obliquely weakly rugose, with setae as in figure; trochanter longer than one and a half times its width; femur about twice as long as wide, obliquely weakly rugulose; length of tibia a little over twice as long as wide, five-sixths the femur, with setae, odontoid spines and a bifid spur as in figure. Tarsi three-fifths the tibia; metatarsus two-thirds the tarsal length. Mid leg (Fig. XII, 123) : Coxa less than one and a half times as long as wide, transversely and obliquely weakly rugose; trochanter less than twice as long as wide, with setae and sensillae as in figure; femur one and a half times as long as wide, obliquely weakly rugose, setae as in figure; tibia claviform, distinctly longer than the femur, about two and four-fifths as long as wide, with setae, odontoid spines and spur as in figure. Tarsi about two-thirds the tibia; fifth segment a little over half the tarsal length. Hind leg (Fig. XII, 124): Coxa a little over one and three-fourths as long as wide, obliquely weakly rugose, setae as in figure; trochanter twice as long as wide, with setae and sensillae as in figure; femur a little over one and two-thirds as long as wide, obliquely weakly rugose, with setae as in figure; tibia long, about three and a half times as long as its maximum width, with setae, odontoid spines and spurs as in figure. Tarsi about three-fifths the tibia; metatarsus half the tarsal length, a little longer than twice its width, its dorsal projecting margin with two very long macrochetae; second segment small, its dorsal projecting margin with two shorter macrochetae; fifth segment shorter than the metatarsus.

Abdomen: Length one and two-thirds its width; the urotergites with a row of long setae; eighth urotergite with a pair of spiracles with small rounded peritremes situated laterally; ninth with a pair of pseudocerci (Fig. XII, 125, R) each with a single seta; genital armature with two ventral, flattened processes (Fig. XII, 125, M), each bearing two setae distally, and a pair of dorsal, depressed, long and distally dilated appendages (Fig. XII, 125, B), each with three short, stout odontoid spines; penis as in figure XII, 125, C.

Measurements

	Form 1	*Form* 2	*Form* 3
Length of body	2·2 mm.	1·9 mm.	1·6 mm.
Length of head	0·62 mm.	0·58 mm.	0·49 mm.
Width of head	0·67 mm.	0·58 mm.	0·46 mm.
Length of pronotum	0·51 mm.	0·49 mm.	0·38 mm.
Width of pronotum	0·68 mm.	0·62 mm.	0·46 mm.
Length of rest of thorax and propodeum	0·36 mm.	0·33 mm.	0·25 mm.
Width of mesonotum	0·60 mm.	0·58 mm.	0·42 mm.
Length of abdomen	0·82 mm.	0·60 mm.	0·57 mm.
Width of abdomen	0·51 mm.	0·45 mm.	0·33 mm.
Length of fore wing	0·22 mm.	0·15 mm.	0·12 mm.
Length of hind wing	0·14 mm.	0·12 mm.	0·09 mm.

Holotype 1 female dissected on slides Nos. 15/7-2, 15/7-3 and 15/7-4; *allotypes* on slides Nos. 15/L-1, 15/L-2; 15/M-1, 15/M-2, 15/S. *Paratypes* females and male in spirit.

Geographical distribution.—Collected by K. J. Joseph from figs of *Ficus palmata* Forsk. from Forest Research Institute Estate, New Forest, Dehra Dun, dated 23rd June, 1953.

Philotrypesis dunia, sp. nov.

Female.—Head, thorax and abdomen with a fundamental sooty-brown colour; antennae somewhat paler; eyes coralline; ocelli pale pinkish; legs melleous except for the coxae which are smoky-brown; the tail-like part of the abdomen brownish-black above; ovipositor-valves smoky-brown; alar membrane hyaline, pubescence dark brownish, nervures amber.

Head (Fig. XI, 98) a little wider between the external margins of the eyes than long, with a somewhat rounded outline; epistomal margin as in figure; lateral margin of head forwards of eyes about half the longitudinal diameter of the eyes and converging forwards; posterior margin of head behind the eyes rounded; antennae inserted near the anterior margin of head, the posterior ends of the toruli lie on an imaginary line connecting the anterior ends of the two eyes; eyes large; ocelli three, in an obtuse triangle. Antenna (Fig. XI, 99) with thirteen segments, of which three form ring-joints; scape a little less than six times as long as thick, and longer than the five following segments combined, with setae as in figure; second segment a little over twice as long as thick, slightly thicker than the scape; the third, fourth and the fifth segments form the ring-joints, each with a whorl of setae; sixth a little longer than thick; seventh a little longer than the sixth; eighth and ninth segments equal; tenth as long as ninth but a little thicker; eleventh, twelfth and thirteenth segments form a club of length equal to thrice its maximum thickness; segments six to thirteen with sensoria and long setae as in figure; antenna somewhat moniliform. Mandible (Fig. IX, 100) a little longer than one and a half times its width, teeth and setae as in figure. Maxillary palpus (Fig. XI, 102) four segmented; labial palpus (Fig. XI, 101) two-segmented; their terminal segments short and ovoid.

Thorax (Fig. XI, 103). Pronotum with its lateral margins a little diverging posteriorly, with a few small setae. Mesonotum with the scutum convex, hardly a little wider than long, with a few small setae; scapula twice as wide as long, convex, with a few small setae; scutellum large and flat, wider than long; axilla distinctly longer than wide, with a few small setae. Length

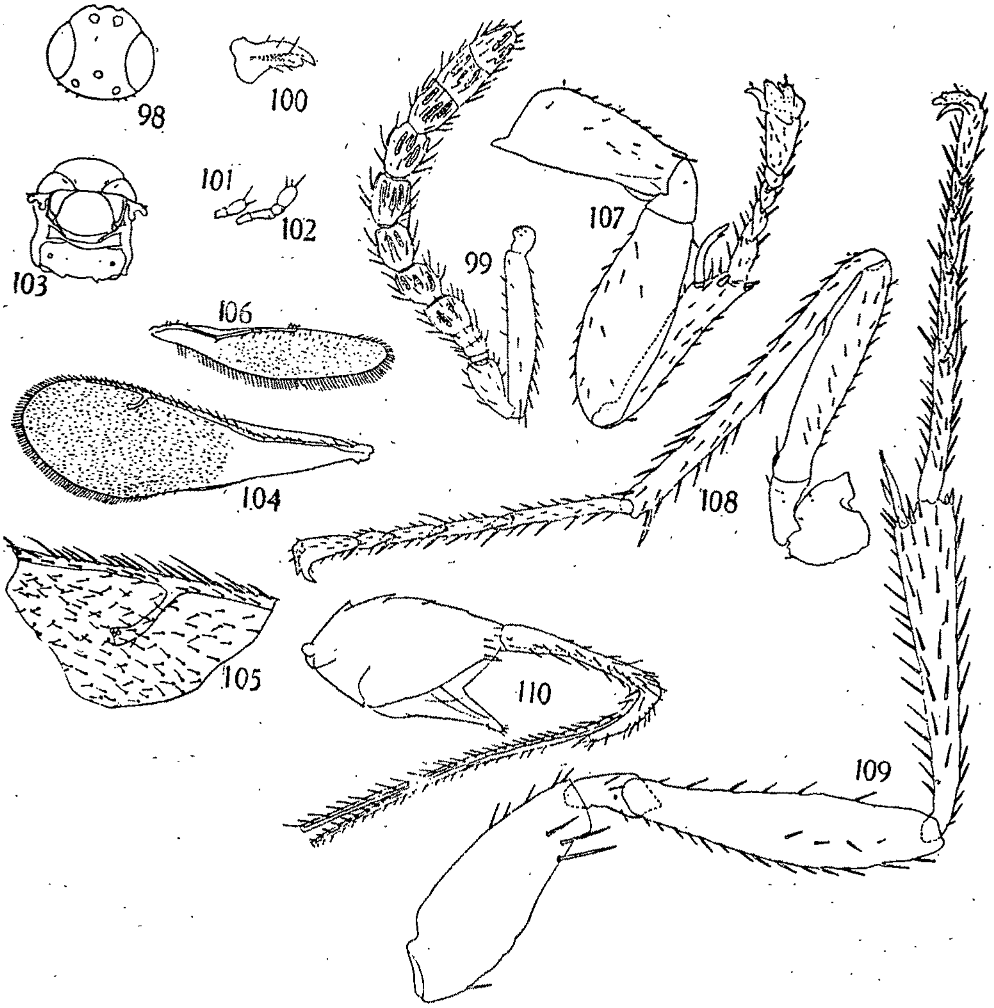


Fig. XI.—*Philotrypesis dunia*, sp. nov. Female : 98, head; 99, antenna; 100, mandible; 101, labial palpus; 102, maxillary palpus; 103, thorax and propodeum; 104, fore wing; 105, details of stigmal vein; 106, hind wing; 107, fore leg; 108, mid leg; 109, hind leg; 110, abdomen.

of thorax and propodeum one and one-fourth as long as its maximum width. Fore wing (Fig. XI, 104) two and three-fourths as long as its breadth; costal cell twelve times as long as its breadth; submarginal vein one and one-sixth as long as the marginal; marginal one and one-third as long as the postmarginal;

postmarginal hardly thrice the stigmal; stigmal vein as in figure XI, 105, with four small rounded sensillae at its distal extremity; pubescence dense, of moderate length; marginal fringe of mediocre size. Hind wing (Fig. XI, 106) a little over four times as long as broad, with three frenal hooks; pubescence in the anterior half of alar membrane longer than those posterior; marginal fringe long. Fore leg (Fig. XI, 107) : Coxa two and one-fourth as long as its width, obliquely and transversely rugose, with a few setae; trochanter longer than wide; femur thrice as long as its maximum width, longitudinally weakly rugose, shorter than the coxa and the trochanter combined; with setae as in figure; tibia shorter than the femur, about five and a half times as long as its maximum width, with setae, odontoid spines and a long bifid spur as in figure. Tarsi four-fifths the femur; metatarsus equal to the two following segments combined. Mid leg (Fig. XI, 108) : Coxa one and one-fourth as long as wide, transversely rugose; trochanter about twice as long as wide; femur five and a half times as long as its maximum width, obliquely weakly rugose, setae as in figure; tibia long, fourteen times as long as wide, one and a half times as long as the femur, with setae and a long apical spur as in figure. Tarsi a little shorter than the tibia; metatarsus a little longer than the two following segments combined. Hind leg (Fig. XI, 109) : Coxa long, two and two-thirds as long as wide, obliquely rugose, with three macrochetae on its outer face distally; trochanter a little over twice as long as wide, with setae and sensillae as in figure; femur a little over four times as long as its maximum width, transversely weakly rugose, with three specialized setae on its outer face, other setae as in figure; tibia longer than the femur, length a little less than ten times its width, obliquely weakly rugose, with setae, spines and spurs as in figure. Tarsi longer than the tibia; metatarsus longer than the two following segments combined. Propodeum two and five-sevenths as wide as its maximum length, transversely and obliquely rugose, with setae and a pair of spiracles with small rounded peritremes as in figure.

Abdomen (Fig. XI, 110). Length of abdomen upto the seventh tergite one and two-thirds its height; seventh urotergite with a few short setae as in figure; eighth and ninth urotergites with many long setae; tail-like part of abdomen one and one-fourth as long as the abdomen upto the seventh tergite; eighth urotergite markedly shorter than the abdomen upto the seventh segment; ninth over half as long as the eighth; projecting part of the ovipositor longer than the length of urotergites two to nine; ovipositor-valves setiferous.

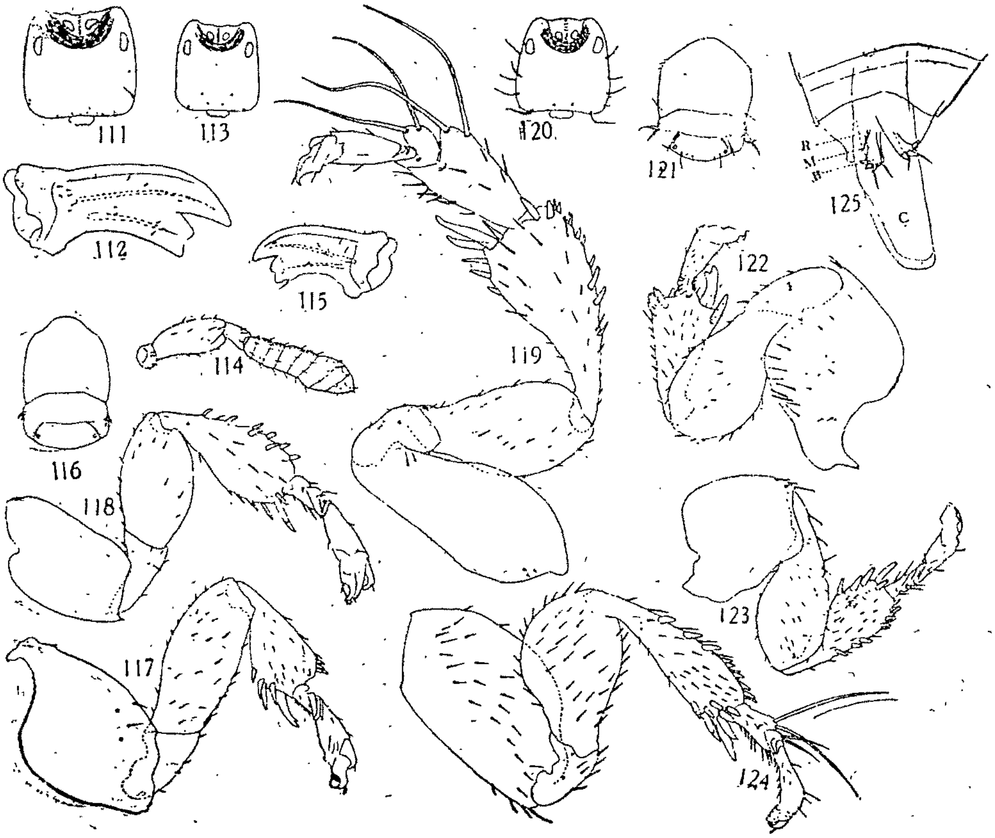


FIG. XII.—*Philotrypesis dunia*, sp. nov. Male, Form 1 : 111, head; 112, mandible. *Philotrypesis dunia*, sp. nov. Male, Form 2 : 113, head; 114, antenna; 115, mandible; 116, thorax and propodeum; 117, fore leg; 118, mid leg; 119, hind leg. *Philotrypesis palmata*, sp. nov. Male, Form 3 : 120, head; 121, thorax and propodeum; 122, fore leg; 123, mid leg; 124, hind leg; 125, eighth and ninth urites, genital armature and penis: lettering as in fig. II.

Measurements. Length of body : 2.61 mm.; length of head : 0.39 mm.; width of head : 0.42 mm.; length of thorax and propodeum : 0.55 mm.; width of mesonotum : 0.42 mm.; length of abdomen upto the seventh tergite : 0.82 mm.: length of eighth urotergite : 0.60 mm.; length of ninth urotergite : 0.34 mm.; length of projecting part of ovipositor : 2.30 mm.; length of fore wing : 1.39 mm.; breadth of fore wing : 0.49 mm.; length of hind wing : 0.92 mm.; breadth of hind wing : 0.21.

Male, Form 1. Colour. Head rusty yellow-brown; eyes black; mandibles brownish-red. *Head* (Fig. XII, 111) hardly a little longer than wide; epistomal margin as in figure; lateral margins weakly converging forwards; posterior margin of head weakly concave; anterior angles of head as in figure, posterior angles broadly rounded; the frontal region posterior to the anterior depression with wavy, semicircular rugosities; dorsum of head with the scars of about a dozen macrochetae (which have fallen off) and many small setae. Mandible (Fig. XII,112) a little over twice as long as wide, tridentate, teeth and setae as in figure.

Male, Form 2. Head yellowish-brown, thorax and abdomen a little paler; mandibles pale brownish-red; antennal scape and pedicel yellowish-brown, rest of antenna yellowish-white; legs with a fundamental yellowish-brown colour, with a rusty yellow-brown tinge for the trochanters and tibiae; eyes black.

Head (Fig. XII,113) distinctly longer than wide; epistomal margin as in figure, similar to that of form 1; lateral margins of head weakly converging forwards; posterior margin of head weakly concave; anterior angles of head as in figure, posterior angles broadly rounded; the frontal region posterior to the anterior depression with wavy, semicircular rugosities; dorsum of head without macrochetae, with a few small setae. Antenna (Fig. XII, 114) with eleven segments; scape short, stout, twice as long as thick, with setae as in figure; segment two longer than one and a half times its thickness; segment three small, thicker than long; fourth twice as thick as long; fifth longer and thicker than fourth, a little thicker than twice its length; sixth as long as the fifth but slightly thicker; seventh distinctly longer and a little thicker than the preceding segment; eighth shorter and thicker than the seventh; ninth, tenth and eleventh segments fused to form a club of length one and a half times its maximum thickness; segments five to eleven with setae and sensoria as in figure. Mandible (Fig. XII, 115) a little less than twice as long as wide, tridentate, teeth and setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. XII, 116). Pronotum a little wider than long, hardly a little wider than the head; anterior margin as in figure; lateral margins weakly converging forwards. Rest of thorax and propodeum about one and a half times as wide as its median length; propodeal tracheal spiracles with small, subrotund peritremes as in figure. Wings much reduced and as in figure. Fore leg (Fig. XII, 117) : Coxa one and four-fifths as long as wide, obliquely weakly rugose; trochanter about one and four-fifths as long as wide; femur a little shorter than the coxa, two and one-third as long as wide, obliquely weakly rugose, with setae as in figure; tibia a little less than two-thirds the femur, twice as long as wide, with setae, odontoid spines and a bifid spur as in figure. Tarsi about two-thirds the tibia; fifth segment five-eighths the entire tarsal length. Mid leg (Fig. XII, 118) : Coxa about one and a half times as long as wide, obliquely weakly rugose; trochanter a little less than twice as long as wide; length of femur a little over one and a half times its width, with setae as in figure; tibia claviform, about two and five-eighths as long as wide, with setae, odontoid spines, and spur as in figure. Tarsi three-fourths the tibia; fifth segment distinctly longer than half the entire tarsal length. Hind leg (Fig. XII, 119) : Coxa about two and one-fourth as long as wide, obliquely weakly rugose, with two macrochetae on its outer face distally as in figure; trochanter one and four-fifths as long as wide; femur twice as long as wide, obliquely weakly rugose, with setae as in figure; length of tibia about two and five-eighths its width, with setae, odontoid spines and spurs as in figure. Tarsi equal to the tibia; metatarsus about three-fifths the entire tarsal length and about twice as long as its own width, its dorsal margin with two long macrochetae as in figure; second segment about half as long as the metatarsus and one and a half times as long as its own width, its dorsal projecting margin with two long macrochetae as in figure; fifth segment about one-third the entire tarsal length.

Abdomen. Length one and a half times its width; eighth urotergite with a pair of spiracles with moderately large, rounded peritrêmes; ninth with a pair of small pseudocerci, each with a seta; genital armature with a pair of ventral, flattened processes, each with a pair of setae at their distal extremities, and two dorsal, depressed, distally dilated appendages, each with three short, stout odontoid spines; penis exserted, sublanceolate.

MEASUREMENTS

	Form 1.	*Form* 2.
Length of body	x	1·6 mm.
Length of head	0·57 mm.	0·47 mm.
Width of head	0·55 mm.	0·40 mm.
Length of pronotum	x	0·38 mm.
Width of pronotum	x	0·42 mm.
Length of rest of thorax and propodeum	x	0·29 mm.
Width of mesonotum	x	0·42 mm.
Length of abdomen	x	0·69 mm.
Width of abdomen	x	0·57 mm.

Holotype 1 female dissected on slides Nos. 19/5-1 and 19/5-3; *allotype* the head and mandibles of a single male of form 1 mounted on slide No. 19/6-1 and 1 male of form 2 dissected and mounted on slides Nos. $\frac{19}{6\text{-s-}1}$ and $\frac{19}{6\text{-s-}2}$. Paratypes three females in spirit.

Geographical distribution. Collected by K. J. Joseph from figs of *Ficus cunia* Hann. from Forest Research Institute Estate, New Forest, Dehra Dun, dated 25th June, 1953.

Philotrypesis travancoricus, sp. nov.

Male, Form 1. Head yellowish-brown; thorax and abdomen pale yellowish-brown; mandibles pale brownish-red; antennal scape yellowish-brown, rest of antenna whitish-yellow; legs pale yellowish-brown with a rusty yellow-brown tinge for the trochanters and tibiae; eyes black.

Head (Fig. XIII, 126) hardly a little wider than long; epistomal margin emarginate in the middle and as in figure; lateral margins of head weakly converging forwards; posterior margin of head concave; the frontal region posterior to the anterior depression without rugosities; head with numerous long macrochetae as in figure; eyes small; toruli of the antennae almost contiguous. Antenna (Fig. XIII, 127) with eleven segments; scape about twice as long as thick, about three and a half times as long as the second segment, with setae and two long macrochetae as in figure; second segment twice as long as thick, with setae distally; third very small, thicker than long; fourth a little longer than thick; fifth a little longer than fourth, as long as thick; segments six to eleven thicker than long; ninth, tenth and eleventh fused to form a club of length one and a half times its thickness; segments five to eleven with setae and sensoria as in figure. Mandible (Fig. XIII, 128) twice as long as wide, apical tooth long and acute, subapical portion with a tendency to be bidentate, setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

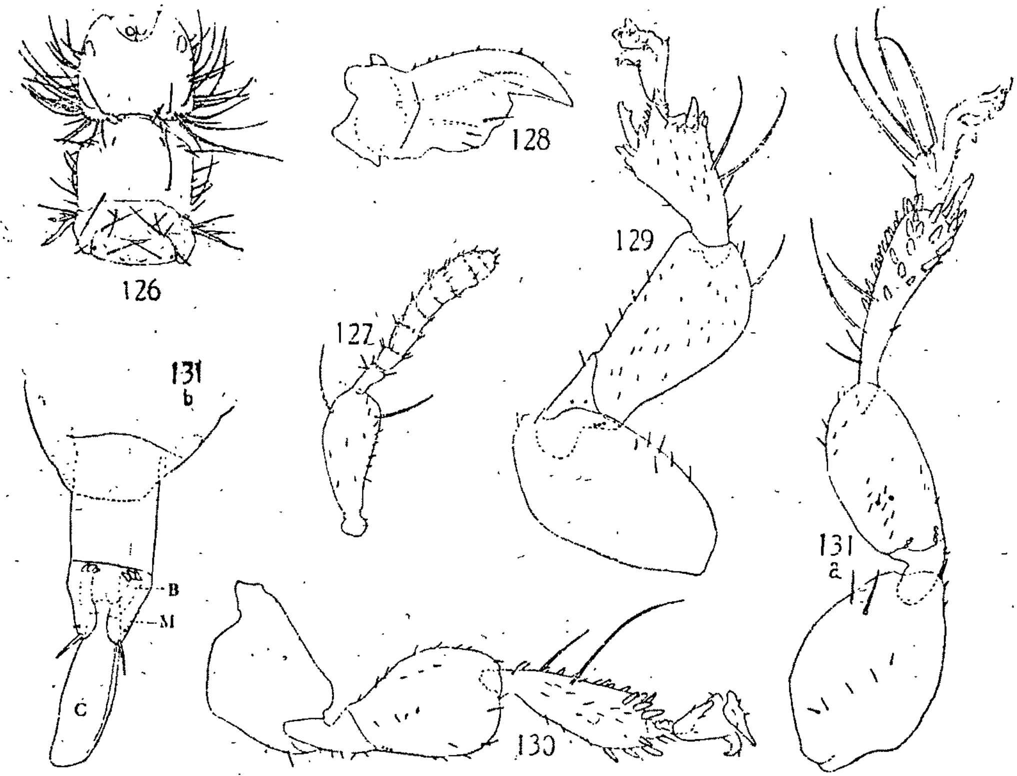


FIG. XIII.—*Philotrypesis travancoricus*, sp. nov. Male, Form 1 : 126, head, thorax and propodeum; 127, antenna; 128, mandible; 129, fore leg; 130, mid leg; 131a, hind leg; 131b, ventral view of eighth and ninth urites, genital armature and penis : lettering as in fig. II.

Thorax (Fig. XIII, 126). Width of pronotum hardly a little less than that of the head; length about four-fifths width, with a few small setae and many long macrochetae laterally, anteriorly and posteriorly; anterior margin as in figure; lateral margins weakly converging backwards. Rest of thorax and propodeum with length equal to three-fifths its maximum width; mesonotum with many long and short macrochetae disposed as in figure; metanotum and propodeum with macrochetae as in figure; propodeal tracheal spiracles with small rounded peritremes. Wings long and narrow; fore wing about one and a half times as long as the hind wing. Fore leg (Fig. XIII, 129) : Coxa less than twice as long as wide, obliquely weakly rugose; trochanter about one and one-third as long as wide; femur about twice as long as wide with setae and a single macrocheta on its dorsal margin as in figure; tibia distinctly shorter than the femur, twice as long as wide, with setae, odontoid spines, a bifid spur and two long macrochetae as in figure. Tarsi longer than half the tibia; fifth segment two-thirds the tarsal length. Mid leg (Fig. XIII, 130) : Coxa about one and two-fifths as long as wide, obliquely weakly rugose; trochanter a little less than twice as long as wide; femur one and two-thirds as long as wide, with setae as in figure; tibia a little longer than the femur, length equal to thrice its own width, with setae, odontoid spines, spur and two long macrochetae as in figure. Tarsi about half as long as the tibia; fifth segment two-thirds the tarsal length. Hind leg (Fig. XIII, 131a) : Coxa a little longer than one and a half times width, obliquely weakly rugose, with two macrochetae on its outer face as in figure; trochanter a little longer than wide; femur twice as long as wide, with setae as in figure; tibia longer than the femur, four times as long as wide, with setae, odontoid spines, spurs and macrochetae as in figure. Length of tarsi a little over half the tibia; metatarsus three-fifths the tarsal length and one and two-thirds as long as its own maximum width, its dorsal projecting margin with two long macrochetae; second segment small, its dorsal projecting margin with two long macrochetae; fifth segment equal to metatarsus.

Abdomen about one and a half times as long as wide; each of the urotergites with a row of long setae; eighth urotergite with a pair of spiracles with small rounded peritremes; genital armature with a pair of ventral, flattened processes (Fig. XIII, 131b, M) each with a long seta apically and a minute seta a little to the front, and two dorsal, long, depressed, distally dilated appendages (Fig. XIII, 131b, B) each bearing three short, stout odontoid spines; penis as in figure XIII, 131b, C.

Male, Form 2. *Colour.* A more brownish form than the preceding. *Head* (Fig. XIV, 132) hardly a little wider than long; epistomal margin as in figure; lateral margins converging forwards; posterior margin concave; the frontal region posterior to the anterior depression without semicircular rugosities; dorsum of head with a few small setae, its lateral and posterior regions with macrochetae as in figure; toruli of the antennae almost contiguous. Antenna (Fig. XIV, 133) with eleven segments; scape about twice as long as thick and about three and a half times as long as the second segment, with two macrochetae as in figure; length of second segment a little less than twice its thickness; third small, thicker than long; segments four to eleven thicker than long, increasing in thickness distalwards; ninth, tenth and eleventh fused to form a club of length a little over one and a half times its maximum thickness; segments five to eleven with sensoria and setae as in figure. Mandible (Fig. XIV, 134) a little over one and a half times as long as wide, teeth as in form 1, setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. XIV, 135). Pronotum hardly a little wider than the head; length of pronotum three-fourths its width, without any conspicuous macrochetae; lateral margins weakly converging backwards. Length of rest of thorax and propodeum a little over half its maximum width, without macrochetae. Wings small and reduced; fore wing one and a half times as long as the hind wing. Fore leg (Fig. XIV, 136) : Coxa over one and a half times as long as wide, obliquely weakly rugose; length of trochanter less than one and a half times its width; femur twice as long as wide, with a few small setae; tibia twice as long as wide, with setae, odontoid spines, a bifid spur and two macrochetae situated as in figure. Length of tarsi a little less than half the tibia; fifth segment about two-thirds the tarsal length. Mid leg (Fig. XIV, 137) : Coxa a little longer than wide, obliquely weakly rugose, with two macrochetae on its outer face as in figure; trochanter twice as long as wide; length of femur twice its width; tibia a little longer than the femur, length thrice its width, with setae, odontoid spines, spur and a macrocheta as in figure. Tarsi a little longer than half the tibia; fifth segment three-fifths the tarsal length. Hind leg (Fig. XIV, 138) : Coxa about one and a half times as long as wide, obliquely weakly rugose; length of trochanter about one and a half times its width; femur about one and two-thirds as long as wide, obliquely weakly rugose; tibia distinctly longer than the femur, three and a half times as long as wide, with setae, odontoid spines, spurs and a macrocheta as in figure. Tarsi longer than half the tibia; metatarsus two-thirds the tarsal length, with two long macrochetae on its dorsal projecting margin; second segment small, with two macrochetae on its dorsal margin; fifth segment about three-fourths the metatarsus.

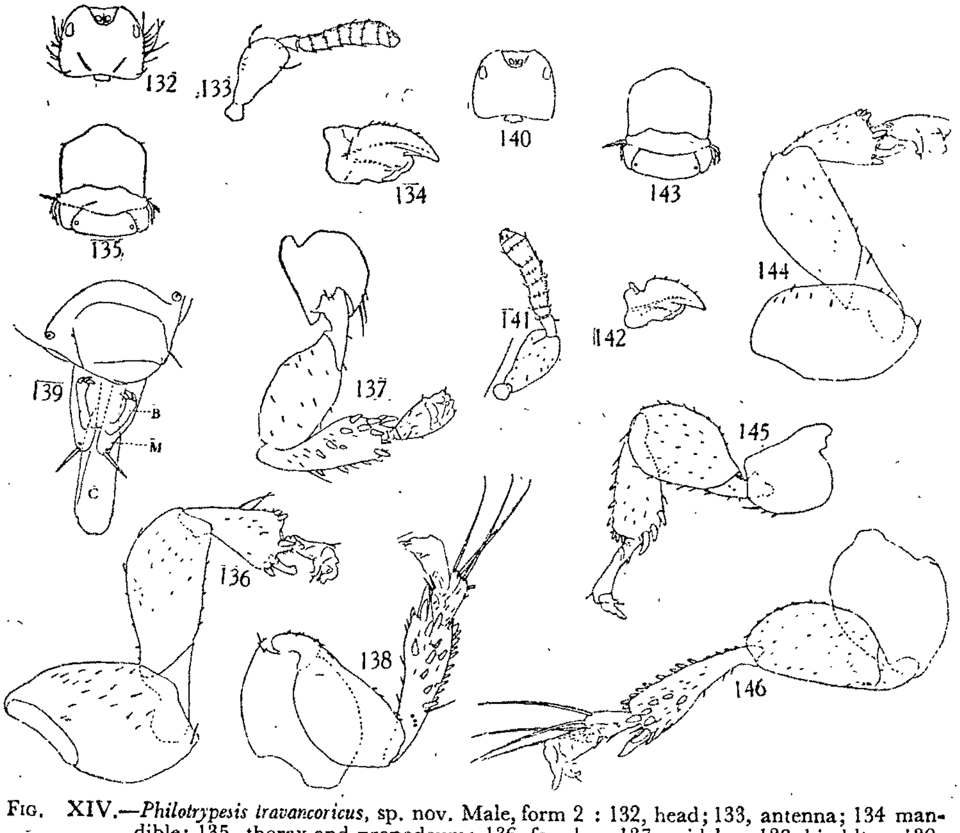


FIG. XIV.—*Philotrypesis travancoricus*, sp. nov. Male, form 2 : 132, head; 133, antenna; 134 mandible; 135, thorax and propodeum; 136, fore leg; 137, mid leg; 138, hind leg; 139, ventral view of eighth and ninth urites, genital armature and penis: lettering as in fig. II. *Philotrypesis travancoricus*, sp. nov. Male, Form 3 : 140, head; 141, antenna; 142, mandible; 143, thorax and propodeum; 144, fore leg; 145, mid leg; 146, hind leg.

Abdomen. Length a little less than one and one-third width; the urotergites without setae; eighth urotergite with a pair of spiracles with small rounded peritremes; genital armature with a pair of ventral, flattened processes (Fig. XIV, 139, M) each with a single long seta apically and a microscopic seta a little to the front, and two dorsal, long, depressed, distally dilated appendages (Fig. XIV, 139, B) each with three short, stout odontoid spines; penis as in figure XIV, 139, C.

Male, Form 3. Colour. A little more brownish than form 2.

Head (Fig. XIV, 140) a little wider than long; epistomal margin as in figure; lateral margins of head converging forwards; posterior margin concave; the frontal region posterior to the anterior depression without semicircular rugosities; dorsum of head with small microscopic setae; toruli of antennae almost contiguous. Antenna (Fig. XIV, 141) with eleven segments; scape about twice as long as thick, thrice as long as the second segment; segment two a little less than twice as long as thick; third small and reduced, thicker than long; segments four to eight thicker than long; seventh and eighth equal; ninth, tenth and eleventh segments fused to form a club of length one and a half times its thickness; segments five to eleven with setae and sensoria as in figure. Mandible (Fig. XIV, 142): Length one and two-thirds width, teeth as in form 2, setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. XIV, 143). Pronotum as wide as the head; length of pronotum a little over three-fourths its width; lateral margins weakly converging backwards. Length of rest of thorax and propodeum over half as long as its maximum width; mesonotum wider than propodeum. Wings small and reduced; fore wing a little longer than the hind wing. Fore leg (Fig. XIV, 144) : Coxa about twice as long as wide, obliquely weakly rugose; trochanter about one and a half times as long as wide; femur a little less than twice as long as wide; length of tibia twice its width, with setae and odontoid spines as in figure. Tarsi over half as long as the tibia; fifth segment two-thirds the tarsal length. Mid leg (Fig. XIV, 145) : Coxa about one and one-third as long as wide, obliquely weakly rugose, with setae as in figure;

trochanter about twice as long as wide; length of femur about one and a half times its width; tibia less than thrice as long as wide, with setae, odontoid spines and spur as in figure. Tarsi a little over half as long as the tibia; fifth segment about two-thirds the tarsal length. Hind leg (Fig. XIV, 146) : Coxa one and one-fourth as long as wide, obliquely weakly rugose, with two macrochetae on its outer face as in figure; length of trochanter about one and one-third its width; femur one and a half times as long as wide; length of tibia three and one-fourth its width, with setae, odontoid spines and tibial spurs as in figure. Tarsi distinctly longer than half the tibia; metatarsus about three-fifths the tarsi and with two long macrochetae on its dorsal projecting margin; second segment small, with two shorter macrochetae on its dorsal margin; fifth segment shorter than the metatarsus.

Abdomen a little over one and one-third as long as wide; eighth urotergite with a pair of tracheal spiracles with small rounded peritremes; genital armature with a pair of ventral, flattened processes, each of which bears a long seta apically, and two dorsal, long, compressed, distally dilated processes, each with three short, stout odontoid spines; penis exserted, sublanceolate.

MEASUREMENTS

	Form 1.	*Form* 2.	*Form* 3.
Length of body	1·6 mm.	1·4 mm.	1·4 mm.
Length of head	0·46 mm.	0·38 mm.	0·36 mm.
Width of head	0·46 mm.	0·40 mm.	0·40 mm.
Length of pronotum	0·34 mm.	0·33 mm.	0·33 mm.
Width of pronotum	0·46 mm.	0·42 mm.	0·40 mm.
Length of rest of thorax and propodeum	0·27 mm.	0·25 mm.	0·24 mm.
Width of mesonotum	0·46 mm.	0·44 mm.	0·43 mm.
Length of abdomen	0·51 mm.	0·47 mm.	0·47 mm.
Width of abdomen	0·34 mm.	0·34 mm.	0·34 mm.
Length of fore wing	0·20 mm.	0·16 mm.	0·11 mm.
Length of hind wing	0·14 mm.	0·11 mm.	0·09 mm.

This species (form 1) is readily distinguished from *P. tran-*

siens (Walk.)* in which (i) the head is a little longer than wide; (ii) the toruli of the antennae are wide apart; (iii) the thorax has fewer number of macrochetae; (iv) the fore femur is about equal in length to the coxa and a little longer than the tibia; mid femur one and a half times its maximum width, about as long as the coxa and a little longer than the trochanter.

Holotype 1 male of form 1 dissected on slide No. 7 &8/8b-1; 1 male of form 2 dissected on slide No. 7 &8/8d-1; 1 male of form 3 dissected on slide No. 7 &8/8c-2. *Paratypes*: 4 males of form 1 and 1 male of form 2 in spirit.

Geographical distribution. Collected by K. J. Joseph from the figs of *Ficus bengalensis* Linn. from the Botanical Gardens, Trivandrum, dated 15th June, 1950.

Philotrypesis tridentata, sp. nov.

Female.—Head, thorax and abdomen fundamentally yellowish-brown; mandibles brownish-red; antennal segments two to thirteen, ovipositor-valves and alar pubescence smoky-brown; eyes and ocelli coralline; alar membrane hyaline, nervures amber; abdomen above each segment with a large brownish-black band; tail-like part of abdomen brownish-black above.

Head (Fig. XV, 147) distinctly wider between the external margins of the eyes than long; epistomal margin as in figure; lateral margin of head forwards of eyes five-eighths the longitudinal diameter of the eye, somewhat rounded and converging forwards; posterior margin behind the eyes broadly rounded; eyes large; ocelli three; an imaginary line connecting the anterior ends of the two eyes bisects the antennal toruli into an anterior two-thirds and a posterior one-third; dorsum of head with a few short setae; anterior, genal and posterior regions of the cranium rugulose. Antenna (Fig. XV, 148) with thirteen segments, of which three form ring-joints; scape five times as long as thick and distinctly longer than the five following segments combined, with setae and sensillae as in figure; length of second segment one and four-fifths its thickness; third, fourth and fifth form ring-joints;

---

*Grandi, 1930, *Boll. Lab. Ent. Bologna* **3** : 170-171.

sixth about one and a half times as long as thick; seventh a little longer and thicker than the sixth; eighth and ninth equal, shorter than the sixth; tenth shorter than ninth but thicker; eleventh, twelfth and thirteenth form a club of length twice its maximum thickness; segments six to thirteen with short and stout and long and slender sensoria and with long setae as in figure. Mandible Fig. XV, 149) a little less than one and a half times as long as wide, distinctly tridentate at apex, teeth and setae as in figure. Maxillary palpus four-segmented; labial palpus two-segmented.

Thorax (Fig. XV, 150.) Pronotum short, its lateral margins diverging posteriorly as in figure. Mesonotum with the scutum transversely rugulose, distinctly wider than long, with short setae; scapula transversely rugulose, a little wider than long, with setae

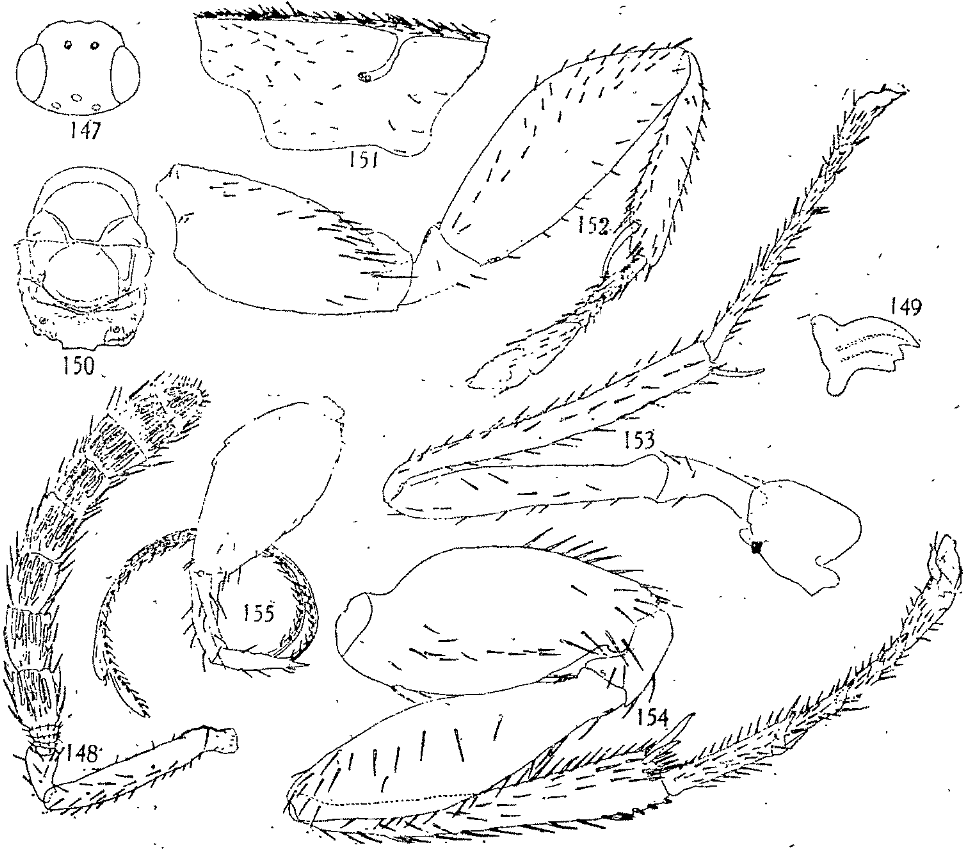


FIG. XV.—*Philotrypesis tridentata*, sp. nov. Female ; 147, head; 148, antenna; 149, mandible; 150, thorax and propodeum; 151, details of stigmal vein; 152, fore leg; 153, mid leg; 154, hind leg; 155, abdomen.

as in figure; scutellum flat, wider than long, with a few very short setae; axilla a little longer than wide, obliquely rugulose, with a few short setae in its posterior angle. Length of thorax and propodeum less than one and a half times its maximum width. Length of fore wing two and a half times its maximum breadth, distal extremity rounded; costal cell about ten times as long as wide; submarginal vein one and two-thirds as long as the marginal; marginal one and two-fifths as long as the postmarginal; postmarginal thrice the stigmal; stigmal as in figure XV, 151, with four rounded sensillae at its distal extremity; alar pubescence sparse, marginal fringe short. Fore leg (Fig. XV, 152) : Coxa a little over twice as long as wide, transversely rugose, with setae as in figure; trochanter a little longer than wide, with a few sensillae and setae; femur large, a little over two and a half times as long as its maximum width, longitudinally weakly rugulose, shorter than the coxa and the trochanter combined, with setae as in figure; tibia hardly as long as the coxa, a little less than five times as long as its maximum width, with setae and long spines on the inner face as in figure and two odontoid spines on its outer face apically. Length of tarsi two-thirds the tibia; metatarsus equal to the two following segments combined. Mid leg (Fig. XV, 153): Coxa a little longer than wide, transversely and obliquely rugulose; trochanter twice as long as wide, with sensillae and setae as in figure; femur six times as long as its maximum width, obliquely weakly rugulose; tibia long, a little shorter than the trochanter and femur combined, longitudinally weakly rugulose, ten times as long as its maximum width, with setae, spines and spur as in figure. Tarsi distinctly shorter than the tibia; metatarsus equal to the two following segments combined. Hind leg (Fig. XV, 154) : Coxa a little over twice as long as wide, obliquely rugulose, its outer face with five macrochetae; trochanter a little over twice as long as wide, with sensillae and setae as in figure; femur about three and a half times as long as its maximum width, longitudinally weakly rugulose; tibia a little longer than the femur, about five and three-fourths as long as its maximum distal width, longitudinally weakly rugulose with long setae, odontoid spines and apical spurs as in figure. Tarsi hardly as long as the tibia; metatarsus a trifle shorter than the two following segments combined. Width of propodeum a little less than thrice its maximum length, obliquely weakly rugulose, with setae and a pair of spiracles with small rounded peritremes situated as in figure.

Abdomen (Fig. XV, 155). Length of abdomen upto the seventh tergite one and two-thirds its height; sixth and seventh urotergites with a few long setae; eighth and ninth with long and strong setae as in figure; the tail-like part of the abdomen a little longer than the length of the abdomen upto the seventh tergite; eighth urite short, three-fifths as long as the length of the abdomen upto the seventh tergite; ninth about two-thirds the eighth; ovipositor comparatively short, its projecting part longer than the length of the urites two to nine; ovipositor-valves strongly setiferous, much swollen at the tip.

Measurements. Length of body : 3.2 mm.; length of head : 0.51 mm.; width of head : 0.62 mm.; length of thorax and propodeum : 0.95 mm.; width of mesonotum : 0.68 mm.; length of urotergites two to seven : 0.92 mm.; length of eighth urotergite : 0.55 mm.; length of ninth urotergite : 0.38 mm.; length of projecting part of ovipositor : 2.48 mm.; length of fore wing : 1.7 mm.; breadth of fore wing : 0.68 mm.

Holotype 1 female, dissected on slides Nos. 20/7-1 and 20/7-2.

Geographical distribution. Collected by K. J. Joseph from the figs of *Ficus benjamina* Linn. from the Forest Research Institute Estate, New Forest, Dehra Dun, dated 29th June, 1953.

UNISEXUAL VARIATIONS AND POLYMORPHISM

This interesting phenomenon, first discovered in the genus by Grandi*, is seen in the males of five of the above species, viz., *P. quadrisetosa* (Westwood), *pilosa* Mayr., *palmata* Joseph, *dunia* Joseph and *travancoricus* Joseph. It is characterized by morphological features such as : (1) *Variable size and shape.* In the males of the same species one can readily recognise a considerable variation in size, ranging from giant forms through medium-sized ones to the dwarfs, which are respectively the *eumegetic*, *epimegetic* and

---

*GRANDI, 1930, *Boll. Lab. Ent. Bologna*, **8** : 38-45.

hypomegetic forms of Grandi. In the giant forms the head tends to become distinctly wider than long, transverse and massive (Fig. II, 13; IX, 81); in the medium-sized individuals the head may be about as wide as long, while in the pigmy-sized ones it tends to become longer than wide (Fig. V, 50; XII, 120) and rounded at their anterior angles, thus assuming a somewhat rounded outline (Fig. V, 50; XIV, 132 & 140). (2) *The degree of reduction undergone by the wings.* The wings, though reduced, are in the majority of forms, long and slender, the fore wing being a little longer than the hind wing. This is the *leptopterous* condition (vide Fig. II, 17 & 18; IV, 38; IX, 89). A clear reduction in the length of the wings but not in width is seen in a few cases (vide Fig. XII, 116; XIII, 126; XIV, 135 & 143; IX, 84; X, 93; XII, 121) and is thus the *brachipterous* condition. The fore wing is the first to undergo conspicuous reduction in length; in *P. quadrisetosa* (Westwood) form 2, it is short and stumpy but retains its normal width (vide Fig. V, 51). (3) *Reduction in number and size of macrochetae, setae and odontoid spines.* With the reduction in size of the individuals, there is a corresponding diminution in the number and size of the macrochetae, setae and odontoid spines borne on the different parts of the body (cfr. figures for *P. quadrisetosa* (Westwood), *travancoricus* Joseph, *palmata* Joseph, *dunia* Joseph.

ORGANIC EVOLUTION : SOME ADDITIONAL NOTES*

By M. S. Mani, M. A., D. Sc., F. R. E. S., F. L. S., *Professor of Zoology & Entomology, School of Entomology, St. John's College, Agra.*

In an earlier paper I[1] examined our ideas on organic evolution in the light of recent advances in biology and like MacBride, urged the need for reopening discussion on basis of the unjustly discredited Lamarckism. The complete incompetence of darwinian theories was demonstrated from an unexpected angle. Conclusions of sufficiently startling nature result by focussing our attention on recent developments in biology and necessitate rejection of agelong assumptions regarding variation, heredity and adaptations, which we have almost come to regard as facts. Throwing new light on the nature and origin of adaptations, the direct role of environment in moulding and transforming organisms was stressed. It was also indicated that discussion on lamarckian basis in no way involves denial of the undoubted importance of the recent contributions of geneticists. It was argued on the other hand that modern genetics is meaningless except on basis of total rejection of darwinian theories and discussion on lamarckian principles. The wide interest the paper has created in many lands, but specially in the United States of America, is perhaps an indication of the dissatisfaction with our current predominating trends in biology. Numerous correspondents have expressed agreement with the ideas, the documentation and analysis of facts, the synthesis of arguments and the general conclusions contained in that paper.

Recent advances in biology, especially in the fields of biochemistry, cytochemistry, endocrinology, experimental embryology, cecidology, cancer research, bacteriology, parasitology, immunology, comparative physiology, tissue culture investigations, genetics and the biology of aging and senescence are essentially against the mutation-natural-selection or the socalled

---

*Contribution No. 43 from the School of Entomology.

[1] Mani, M. S. 1953, *Agra Univ. J. Res.* (Sci.) 2 (1) : 83-112.

Weismann-Mendel-Morgan theory of evolution (Neo-Darwinism). We need not therefore have to feel particularly indebted to Lysenko and we may even for the time being wholly ignore his rhyes and oats, his *durum* and *vulgare* wheat conversions, vernalisations, mentors, vegetative hybridisations, his michurinist philosophy and his numerous other "extravagant claims". Lysenko's criticism of the ordinarily accepted notions may perhaps be somewhat crude, largely politically tinted and to a certain extent unscientific in the orthodox sense. The theory of natural selection, in all its variations, however, stands condemned entirely on its own merits.

We do not even seem to be conscious of the fact that more than a quarter of century ago, it became readily apparent to a great many biologists that the Roux-Weismann germplasm theory is not compatible with contemporary advances. Yet even today we continue to be under the spell of the "smashing experimental proof" provided by Weismann against Lamarck and quite unconsciously admit the germplasm as the sole carrier and maker of destiny of organisms. We still seem to be greatly afraid of the non-existent "acquired" and "non-adaptive" characters. The situation is rather unfortunate, because owing to conflict of political ideologies in certain countries even outside the "iron-curtain" freedom of thought in science is now virtually denied to individuals who hold views in favour of inheritance of "acquired" characters. Biological science has made enormous advances in recent years in many directions and we are dimly becoming aware of the very nature of life itself, but with regard to the problem of evolution we seem to be content with century-old and wholly illogical concepts.

Over-emphasis on structure has to a great extent prevented correct appreciation of the great importance of the dynamic changes, the processes, the energy transformations, metabolism and functions that underlie and determine structure. "We shall do well to give up all that old arguments about form and matter, replacing them by two factors more in accordance with what we know of the universe, *i. e.*, organization and energy.[1]" The same processes result in widely different structural variations and the same structure originates from a great variety of functions. A very large number of the socalled heritable variations in structure are really not inherited at all and have no genetic basis, but result inevitably from growth and functioning under definite conditions of environment during development of an organism. D'Arcy W. Thompson[1] has ably demonstrated how the astonishingly and often enchantingly beautifully proportioned and nearly geometrically perfect shapes of organisms like *Nodosaria*, *Diflugia*, *Stentor*, Radiolaria, Heliozoa, collared cells, Choanoflagellata, Campanularia and the exquisitely delicate forms of jellyfishes and the grotesquely attenuated bodies and bizaarre outgrowths on abyssal fishes like *Lamprotoxus flagellibarbis* are all wholly directly moulded and fashioned by the peculiar hydrodynamic and functional conditions of the environment during development. Flagella, cilia, chitinous setae and other similar structures do not owe their origin and existence to genes, their mutations and their interactions, but arise inevitably in the course of development on surface which would otherwise be unstable, where surface tension would be lowest if or when that surface was ever a liquid. The ciliary rim of a rotifer is merely a mechanism that stabilises and steadies the semifluid mass in its otherwise unstable configuration. The unduloid develops when spheres or cylinders break up and the forms of various species of *Vorticella* are merely unduloids of nearly every gradation. The socalled specific shapes of *Vorticella* spp., assumed to be based on genetic variations preserved by an all-powerful natural selection, readily metamorphose one into another when the external conditions change during growth and development The complexity and intricate and endless patterns of the venation of wings of insects, of so much taxonomic importance and so commonly attributed to natural selection, merely arise according to the well-known mathematical laws of surface partitioning under various stresses and strains during development. The very structure and arrangement of parts of a cell and their apparent behaviour during its growth and division are the result of the dynamic conditions of viscosity, permeability, surface tensions and other purely physical and chemical factors of exogenous origin, not at all determined by or in any way correlated to the gene system. Most if not all the intracellular phenomena, on which biologists have so long laid so much exclusive emphasis, have little biological significance, but follow from some of our initially erroneous assumptions regarding the nature of cell. The chromosomes, their numbers, arrangement and apparent constancy are not related to the organism in the way we have so far assumed and their behaviour in cell division, the rates of uncoiling in different parts of the same chromosome and various other peculiarities are not just gene mutations and spontaneous accidents but are purely byproducts of the manifestation, combinations and permutations of external physical forces such as can be readily reproduced under suitable conditions even in non-living things. Cell division is really reconstruction of the cell as a direct reaction to the physical and chemical conditions created by it in the immediate environment and is wholly unrelated to the action of genes. Unlimited cell proliferation is possible only in presence of unlimited material and *a cell is constantly adjusting itself to the changes it sets up in the immediate environment or created by it during its very functioning or by the functioning of other cells*, viz. the continuous accumulation of metabolic products of the cells themselves, thus creating a metabolic gradient. Mutual exchanges between cells and environment lead on to differentiation of cells and culminates in senescence. This accumulation of metabolic products is the direct consequence of the functioning—its use in the organism. This material inhibits further growth of the cell beyond its functional capacity and in turn releases the growth and division or functioning of some other cells or system of cells. Each cell may in a sense be described as an endocrine system which controls and regulates itself as well as every other cell and the organism as a whole. The growth and maturation of any particular cell and its functioning are initiated and rigidly controlled by its functional relation to others. The cells thus alter their environment and the latter in turn control the cell. Viscocity changes arising from outside factors largely determine the behaviour of the nucleus in cell division. The breaking up of the nucleus from a diminution of the surface tension is accompanied by diffusion and the very arrangement and distribution of the chromosomes on the equatorial plate can be predicted purely on physical and chemical grounds in which genes play no part. The familiar undulating membran of certain species of *Trypanosoma* does not owe its origin to the mutation of a certain single gene for some unaccountable reason in a form that originally lacked the undulating membrane and was unfi darwinically. It arises every time under the direct influence of capillary forces—the surface layer of the protoplasm springing up in a film to run up and along the flagellum when it moves, waves an comes to lie near and parallel to the body. It is the result of functioning and developing under certain external conditions: it is a liqui film and obeys the laws of constant mean curvature. The spira muscles of the vertebrate heart are the direct outcome of the twisting which this tubular organ undergoes in course of developmen and not because an imaginary gene mutated.

---

[1] NEEDHAM J. 1942. Biochemistry and Morphogenesis. Cambridge University Press.

---

[1] THOMPSON, D'ARCY W. 1942. On Growth and Form. Cambridge University Press, pp. 1—1116.

We seem to be greatly puzzled by the origin of structures fo future functioning. *To generally assume genetic control as a guiding or moulding principle in structure is a fallacious simplification.* Th fact that ovum or zygote develops into a complex structure i neither proof that it is itself structurally complex or that comple latent forces reside within it in the shape of genes. Such an assumption is highly reminiscent of the now defunct "homunculus' theory. The development of an organism is a chain reaction— a chain reaction commencing with autocatalysis of complex protein molecules, in which each process sets off in turn the next The development of one part is either inhibited or in some othe manner rigidly controlled by the development and functionin of another. Until one part has either developed or functioned the development and functioning of another cannot be initiated Until the first phase is over there is no second. This is due to th functional dominance—a dominance which maintains the organism as a functional and structural unit. *In any organism a pa that is functioning acquires dominance over others*—other similar re gions within a certain distance of itself and prevents a certai kind of reconstitution, inhibits it to a greater or lesser extent o causes regression and destruction of parts already structurall differentiated. A part that is functioning relatively fast i dominant over a slower; a part with relatively high intensity c metabolism is dominant over another with less intense metabolism

The formation of a new pattern of development obliterates an old one which has almost ceased functioning. Even if a new dominant region arises independently of other parts, the scales of organisation and the structural pattern are profoundly affected by other parts. The dominance of a functioning part and the gradient associated with it are primarily dynamic and not at all structural; metabolism rather than structure is the primary factor that determines developmental patterns. All available evidence shows that at least in the case of embryonic inductors, axiate patterns of development are quantitatively graded in the early stages of development. A slight difference in oxygen tension determines, for example, the functional difference and this in turn structural difference. Inductors are at certain stages of development of embryo merely levels of high functional (metabolic) gradient zones. They induce by altering the conditions in low gradient zones; this alteration is activation. The amphibian head-, trunk- and tail-inductors are, for example, merely different gradient levels of metabolism. The great many agents that can initiate the amphibian neural tube induction strongly contradicts the possibility of specific substances, but indicates quantitative gradient levels action. With progress of differentiation, however, induction naturally becomes increasingly specific, both for the inducing factor and for the reacting system and specific substances then become evident. These substances arise in the course of differentitation and functioning of parts already structurally visible and these in turn now produce specific effects on other parts. *Developmental pattern is throughout a reaction of the protoplasm to environmental factors either within the organism or outside it.* Independence of developmental pattern from the effects of environment involves the illogical assumption that pattern is constantly present as spatial patterns through all divisions of cells, generation after generation, or this pattern originates spontaneously. Roux-Weismann germplasm theory utterly breaks down and completely fails to account for and explains the determination and control of the orderly sequence of development of an organism. The germ and the genes which have been assumed to be the sole carriers and *makers* of our destinies and heredities, should actually be endowed with "astonishingly superhuman intelligence and with knowledge of the end to be attained in order to get each hereditary determinant into its proper cell and to supply the cell with accessory determinants to provide for possible regeneration".[1] Nuclear polarity seen in chromatin aggregation in regions of nuclear periphery is also a reaction to something outside the nucleus and genes do not originate autonomously a spatial pattern in the cytoplasm. Since the cell is assumed to inherit the whole of the germplasm, if different gene effects occur in different cells or in different parts of the same cell, the genes must appear to be localised, a conception that is wholly precluded by the fundamentals of genetics. Whatever may be the real nature of embryonic patterns, it is abundantly clear that it does not arise spontaneously or autonomously in the zygote but it originates in relation to the intra-organismic environment—in direct relation to the factors of relation of the oocyte to the parent organism. In a recent work Crick & Huges[2] have shown that there is no justification for assuming organized framework and structure in protoplasm and all such structures are transient affairs in normal cell. The idea of cytoplasmic stratification controlled by the gene system postulated some time ago by Goldschmidt[3] really however involves a regional qualitative and quantitative metabolic difference. These differences rather than simple cytoplasmic stratification, if there be really any, are the factors. In any case Mendelian heredity is completely unable to provide developmental patterns.

Use—functioning—establishes a relatively high metabolic gradient and is followed by material diffusion and transformations. Another nearby region less used now occupies a level of low metabolic gradient. It is functional dominance that is directly responsible for the transformation of organisms. Except in the case of minute organisms, whose forms are due to direct action of molecular forces, the form of organism is in general a function of growth—differences in growth rates in different directions. These differences constitute gradients and heredity plays no part in their origin. By his system of cartesian co-ordinates,

---

[1] CHILD, C. M. Patterns and Problems of Development. The University of Chicago Press, Chicago : Illinois, p. 645. Little wonder Lysenko characterises this concept as idealistic.

[2] CRICK, F. H. & A. F. W. Hughes. 1950. *Expl. Cell. Res.*, **1** (1) : 37-80.

[3] GOLDCHMIDT, R. 1938. Physiological Genetics. pp. 200-262

D'Arcy W. Thompson[1] has beautifully demonstrated how variations proceed on definite and orderly lines and under the direct influence of environmental conditions created by the functioning of the organism itself. Structural variations are due to metabolic and functional changes, involving changes in gradient patterns arising from differential physiological effects of external forces on gradient patterns. The evolution of the different types of larvae of Echinodermata has, for example, no genetic basis, but certain degrees of differential inhibition of the asteroid larval development with an agent such as lithium chloride gives pluteus forms and with less extreme differential action the crinoid type of larva. Structural variations are largely the result of quantitative differential alterations of the metabolic gradient patterns. Thompson co-ordinate system demonstrates forcibly the transformation of the pithecoid skull into the hominid type as a result of such alterations in gradient patterns. Instead of an assumed series of "brain mutations" the increased use of the brain establishes a relatively high functional dominance of the cranium over the facial parts and leads on to a new gradient pattern (metablolic gradient). This is followed by a functional subjugation of the facial parts and gradual regression transforms the skull.

In the light of the remarkable achievements in the fields of developmental physiology and experimental embryology, even if for the moment we lay aside the results from other fields, it seems really very unfortunate that in addition to assuming genetic control of all structural developments, we should also still continue to speak in terms of complete and absolute independence of the germ. *To go on asserting that the germ is in no way affected by the changes in other parts of the organism and to attribute to the germ alone all inheritance, is betrayal of total ignorance of current developments in biology.* The organism, no matter to what state of organisation it belongs, plant or animal, low or high in the scale of phylogeny, is a complete causal unit for all functions. Heredity is no monopoly of the socalled germ cell, to which indeed the application of the term cell is most inappropriate in modern context.

---

[1] THOMPSON, D'ARCY W. 1942. On Growth and Form, pp. 1206-1095. The limitations to Thompson's co-ordinates pointed by Huxley (1932. Problems of Relative Growth, New York) are however no objection to our main argument.

Heredity belongs to the organism as a whole and not specially only to a largely statistically imaginary part of it. Heredity arises and varies in the whole organism. *No part of an organism is independent; what one part does or what happens to it affects every other part and the organism as a whole.* An organism is a unique, completely interlocked, interlinked, interdependent, mutually reacting and adjusting dynamic system of processes and functions, in which structure is purely of secondary significance. We divide the body of an organism into skeleton, bones, muscles, organs, tissues and so on for the sake of convenience in study and have unfortunately come to regard this purely mental process into actual independence of parts.

The darwinian concept of variations, their nature, origin and preservation is no more than a crude attempt at simplification of the results of a very limited series of observations, largely based on utterly erroneous assumptions regarding the nature of the processes involved. Variations are not just the inevitable, unaccountable, spontaneous, statistically fortuitous differences in structure and form, but *they are continuous adjustments of an organism to the continuous changes that arise in or it itself creates by its functioning in the environment: all variations are thus adaptations.* The statistical randomness and the general approximation to the "normal curve" within certain limits, is really no proof of the spontaneous origin of variations. The well-known statistical peculiarities of variation on the other hand merely indicate the action of innumerable, co-existent, non-too-predominant factors, each of which produces its several deviations, potent in their combinations and permutations. From what has been discussed above, it is also clear that the distinction that is supposed to be absolute between the socalled non-heritable or phenotypic variations and the heritable or genetic variations is wholly artificial. Visible structural variations being no more than graphic diagrams of the invisible chemical, metabolic and functional variations, their inheritance is long preceded, determined and controlled by functional variations. *We merely deal here with different phases of a fundamentally single process of adjustments to changing environmental conditions and a dynamic stabilisation of these adjustments at any given time.* These are continuous chain processes and an adjustment to any given set of conditions becomes gradually stabilised. This stabilisation is by no means absolute but is really in the nature of a dynamic equilibrium. *The temporary stabilisation constitutes heredity : heredity is therefore the sum-total of the reaction of an organism to the environmental changes of the past.* Adaptations should not therefore be understood in the narrow darwinian sense as merely protective; *adaptations are direct reactions and adjustments of an organism to changing conditions of life.* We have a remarkable illustration of this in the behaviour of certain common Protozoa. The green flagellata are usually photoautotrophic but the majority utilize certain complex organic compounds when these are available in the environment. Most species are for example capable of utilising acetates, many can make use of butyrates and some even capable of utilizing any organic acid from acetates to laurates. While a great many species can synthesize amino acids from nitrate or ammonia, they also acquire the ability to utilize amino acids if available. The differences are directly correlated with the differences in the composition of the culture media. Species that live in stagnant water, which is relatively rich in organic matter, do not ordinarily synthesize certain essential materials, but can utilize complex compounds. *Polytoma ocellatum* for example utilizes[1] butyric acid. If this species is however cultured in medium lacking butyric acid for prolonged periods, it completely loses this ability. Returning the organism to media containing butyric acid results in gradual restoration of the capacity to use it. That this capacity is not based on gene mutation and chromosome rearrangements and selection follows readily from the very fundamentals of genetics : a reverse mutation is not possible when the capacity is regained. Furthermore if the reverse mutation underlies the restoration of the capacity, the restoration should be sudden instead of being gradual.[2] There can therefore be no element of "chance", and mutations, as now understood, cannot underlie the origin of adaptations. In recent years a number of biologists have realized irrationality of mutational origin of adaptations and have like Waddington tentatively postulated alternative mechanisms such as gene assimilation. Elimination of the Darwinian teleological background leads to recognition of the fact that there are no "acquired" characters, the inheritance of which has to be explained, or "non-adaptive" characters, to serve as handicaps in an imaginary struggle for existence. Cain[1] shrewdly remarks that the socalled non-adaptive characters are really "uninvestigated" characters and sees no justification for assuming either randomness or operation of natural selection.

---

[1] TRAGER. 1941. *Physiol Rev.*, **21** : 1; JOHNSON. 1941. *Quart. Rev. Biol.*, **16** : 336.

[2] In order however to justify the theory of 'selection', we may certainly, but most unnecessarily, assume the action of a gene, which determines the gradual mutation of the gene that controls the ability to utilise butyric acid.

This leads us inevitably to suspect that the chromosome rearrangements, gene changes and mutations should belong to the category of "uninvestigated". Though White[2] dismisses the whole problem of causation of these physico-chemical "accidents" as out of scope, in the light of the foregoing discussion, these phenomena should without doubt be attributed to deeper, far-reaching cytoplasmic changes and changes in body. It is now generally recognized that it is cytoplasm that is completely in control of all the details of nuclear and intra-nuclear changes in cell division. The cytoplasmic environment is essential for the continued nuclear activity and the latter is not insensitive to changes in this environment. Unless we go back to ideas of entelechy, we can scarcely conceive of the independence of nuclear phenomenon. That we fail to see any correlation between these changes and the reactions of the organism to environmental changes is certainly no proof that such a correlation does not exist. Our failure to recognize the secondary importance of mutations is largely the result of the undue over-emphasis we have laid on structure in our discussions on evolution. The socalled mutations are no more 'mutations', but represent secondary phenomenon that accompany the wider process of adjustments of the whole organism to changing conditions of life. We may study variation and heredity as separate phenomenon just as we study bone and muscle separately for convenience and forget that the distinction is purely mental. *If variations arise directly under the influence of environmental conditions and are all thus adaptations, the distinction between useful and useless variations is wholly unjustified.* The total inadequacy of natural selection to create new forms was recognized by several biologists more than a quarter of a century ago, but it was assumed that selection perhaps might account for the disappearance of species. We now realize that even this is wholly unnecessary. Organisms develop and grow according to simple laws so much in harmony with their material and environment and with all internal and external forces to which they are exposed that none is better fitted than another and none less fit to survive. *The whole theory of natural selection in all its forms is an unpardonable, unjustifiable and totally unnecessary fiction.*

---

[1] CAIN, A.J. 1951. *Nature*, **168** : 242.

[2] WHITE, M. J. D. 1945. Animal Cytology and Evolution, Cambridge University Press, p. 4.

Instead of spontaneous variations arising in a few individuals of an otherwise genetically homogeneous population and spreading to the whole in accordance with the undoubtedly brilliant theoretical analysis of Fisher, Haldane, Wright, Hagedoorn & Hagedoorn, Dubinin and Romaschoff and others, variations actually arise simultaneously in whole groups. Whole populations change with changing conditions of life. At no stage do we see misfits, illfits, unfits, useless variations, mutations and certainly no selection at all and what is perhaps rather startling no genetic control in a great many features of development and growth. We have merely to go out into the field to see for ourselves evolution going on right in front of us. *Drosophila* in a milk bottle is undoutedly an extremely interesting laboratory experimental material, but out in Nature—in a pond, a stream or a forest, are going on experiments on much grander scale, complete with more than enough replications and controls. It is literally the whole hill stream that is evolving and not merely an insect or a fish in it; the stream changes and changes everything within it. It is utterly meaningless to speak of the evolution of a pond fish into a torrential fish without the pond at the same time changing into a stream. "The organism and the environment interpenetrate one into another through and through—the distinction between them is only a matter of convenience."[1] An organism is an integral, inseparable, interlocked, interlinked, mutually reacting and adjusting part of the environment. Environment brings it into being, maintains and controls it and it is environment that transforms and reshapes it; the environment in its turn is altered by the organism. *Altered conditions of life lead to changed habits and these in turn to changed structure.*

---

[1] Sumner, F. N. 1922. *Sci. monthly*, **14** : 233.

Our discussions on evolutionary problems are generally characterised by confused thinking and ignorance of fundamentals. Extremely simple phenomena have been rather unnecessarily greatly complicated by certain initially erroneous assumptions, inevitable perhaps from the undue emphasis we lay on structure. Biology today is largely a fast growing mass of ill-digested and partly unassimilated results of very brilliant and intensively specialized, but mostly unco-ordinated research, carried out under predominantly morphological discipline and it has not been possible for all its branches to keep pace with the rapid advances in certain lines. We are indeed still very far from a full realisation of the far-reaching significance of some of the recent developments even in the field of genetics. Hardly ten years ago the gene was a "fixed unit, with well defined boundaries, strung along chromosomes like beads, very stable and immune to external influences. Now the genes are more or less loosely defined parts of an aggregate, which in itself is a *unit* and reacts readily to the influence of environment."[1] The serial structure of chromosomes based on Roux-Weismann and the *corpuscular gene* invented by De Vries, have both been abandoned by Goldschmidt.[2] Yet we are illogical enough to hesitate discarding the wholly erroneous concept of the independence of the germ. As Conklin observes in 1944, 'living things are analysed into organs tissues, cells, chromosomes, genes, and their functions into tropisms, reflexes and forced movements, while the synthesis of all these elements into the broader aspects of the organism and its relation to environment are too much neglected.' We ignored the direct role if environment, tore the organism out of context and literally faced difficulties at every step. Each new difficulty necessitated new assumptions : viable, useful and useless variations, struggle for existence, survival of the fittest, elimination of the illfitting, selection, mutations and so on. We strayed farther and farther from truth in elaborating, supporting and justifying the unnatural theory of natural selection. In our zeal for Darwin, we are apt to forget Lamarck, who for the first time with remarkable foresight, explained in the face of bitterest opposition and ridicule, that species are not immutable and what is more remarkable put forward the *one* and *only* sensible theory of evolution. Progress of biology has fully vindicated Lamarck.

---

[1] DEMERC, M. 1951 Symposia on Quantitative Biology, Coldspring Harbor, 16 : Foreword.

[2] GOLDSCHMIDT, R. R. 1951. *ibid.*, 1-11.

DESCRIPTIONS OF NEW SPECIES OF GALL MIDGES (ITONIDIDAE : DIPTERA) FROM THE ORIENT*

By M. S. Mani, M. A., D. Sc., F. R. E. S., F. L. S., *Professor of Zoology & Entomology, School of Entomology, St. John's College, Agra.*

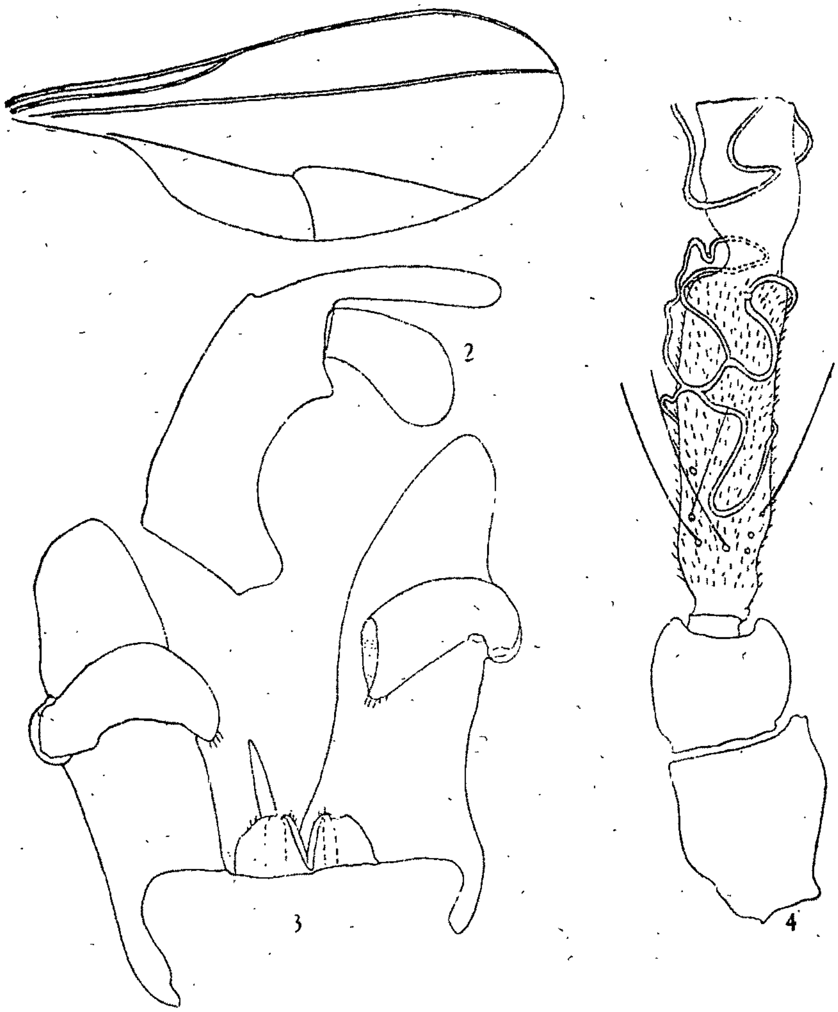
Schizomyia cocculi, sp. nov.

Male.—Length 1.25 mm. Colour in material preserved in formalin brown. Palpus long, slender, moderately densely setose, quadriarticulate excluding the prominently elongate and segment-like palpiger, which is almost as long as the first palpal segment; first palpal segment about half the second segment and nearly as thick; second palpal segment nearly twice as long as thick, slightly reduced apically; third palpal segment elongate, more slender, nearly five times as long as thick and about one and one-fourth the second segment; fourth palpal segment much longer and more slender, nearly six times as long as thick and about one and one-fifth the length of the third segment. Antennae nearly equal to the length of body, pale brown, with 14 cylindrical segments bearing whorls of long setae in addition to the dense short pubescence and with a pair of conspicuously tortuous circumfila; scape short, apical thickness slightly more than length; pedicel subglobose, nearly as thick as scape; third and fourth antennal segments fused together ; third segment nearly four times as long as thick; fourth segment slightly shorter than third segment, with a stem about one-third the length of the segment ; fifth antennal segment somewhat shorter than fourth ; sixth segment equal to the fifth ; segments seven, eight, nine and ten each nearly to the fifth ; eleventh segment slightly shorter and about three-fourths the third segment ; twelfth segment slightly shorter, its stem with a thickness three-fifths its length; thirteenth segment equal to twelfth; fourteenth segment one-fifth shorter than the thirteenth segment. Mesonotum dark brown. Scutellum brown. Legs long; first tarsal segment about one-seventh the second segment; third tarsal segment about half the second; fourth segment about three-fourths the third; fifth seg-

---

*Contribution No. 42 from the School of Entomology; cecidological contribution No. 23.

ment about one and one-fourth the first segment. Claw simple, slender. Empodium equal to claw. Wing as in fig. 10. Abdomen about half the length of body. Genitalia small; dorsal plate deeply bilobed, with the lobes broadly oval, apically broadly rounded; ventral plate equal to the dorsal plate, deeply bilobed, the lobes broadly emarginate; style as in fig. 3; basal clasp segment elongate, moderately stout, prolonged beyond the place of insertion of the terminal clasp segment to nearly the same length as the terminal clasp segment; terminal clasp segment short, stout, subapically inserted on the basal clasp segment, edentate, but with a number short, stiff setae apically.



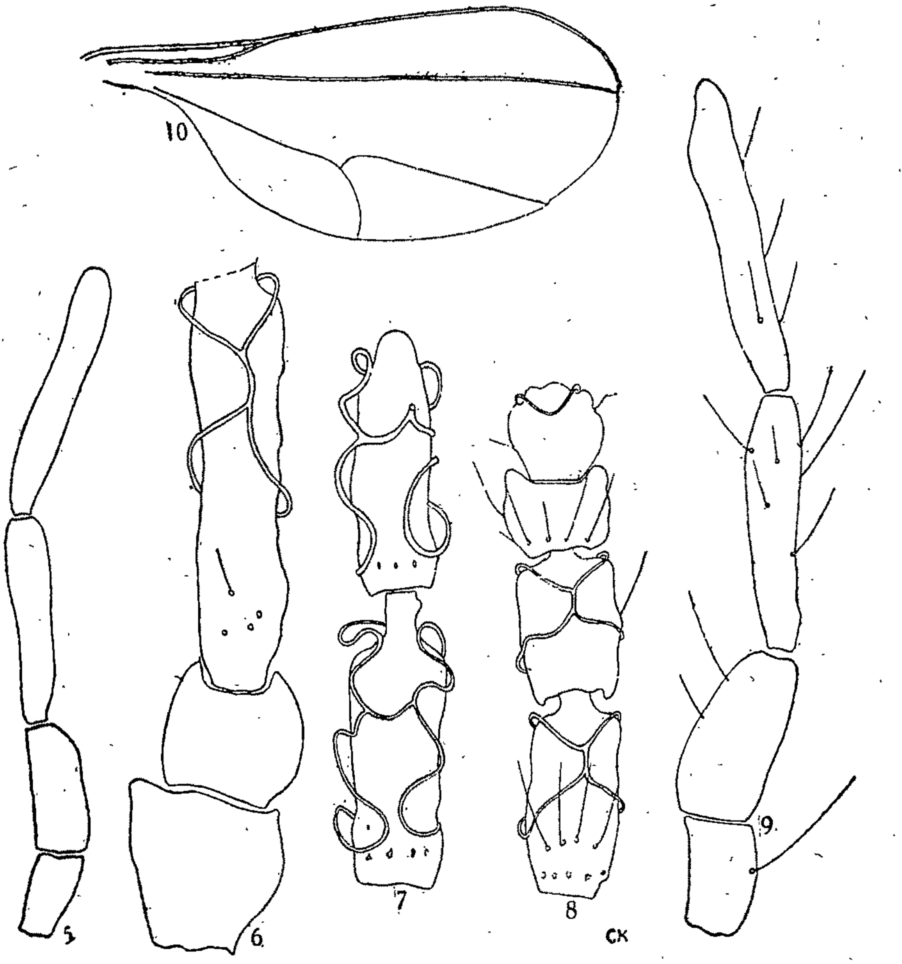
Schizomyia cocculi, sp. nov. FIG. 1. Wing of female. 2. Clasper of male genitalia, lateral view. 3. Male genitalia. 4. Basal antennal segments of male.

Female.—Length 1.25 mm. Brown in preserved specimens. Palpus long, excluding the rather conspicuously elongate palpiger quadriarticulate; first palpal segment cylindrical, stout, nearly twice as long as thick; second palpal segment a little less than twice the length of the first segment; third palpal segment longer, much more slender, a little less than twice the length of the second segment; fourth palpal segment slightly longer than the third segment and about seven times as long as thick. Antennae about three-fourths the length of body, with 14 cylindrical segments, each segment with a short stem, whorls of long setae in addition to short pubescence, circumfila tortuous, terminal antennal segments greatly reduced in size ; scape subcordate; pedicel subglobose; third antennal segment fused with the fourth, nearly five times as long as thick; fourth antennal segment somewhat shorter than the third segment; fifth segment about three-fourths the third segment; segments six, seven and eight each almost equal to fifth segment; ninth segment slightly shorter; tenth segment nearly half the third segment and somewhat shorter than ninth segment; eleventh segment one-fifth shorter than tenth segment ; twelfth segment about three-fourths the eleventh; thirteenth segment about half the eleventh segment; fourteenth segment globose, Mesonotum dark brown. Wing as in fig. 1. Legs long, slender; first tarsal segment nearly one-tenth the length of the second tarsal segment; third tarsal segment almost half the second; fourth segment nearly three times the first segment; fifth tarsal segment about one and a half times the first and about half the fourth segment. Claw simple, slender. Empodium very slightly shorter than claw. Ovipositor protractile, slender, aciculate.

Holotype one male, *allotype* one female, *paratypes* several males and females, on slides and in spirit in the collections of the Zoological Survey of India, Indian Museum, Calcutta. Reared from gall No. 349 on flowers of *Cocculus hirsutus* Diels.* by Mr. S. Ramachandran from material collected by Mr. R. Krishnan, Marudamalai Hills, Coimbatore, South India, 31-xii-1952. The species is parasitised by braconids. A species of the midge *Neolasioptera* is also contained in the same tube and labelled as having

---

*Mani, M. S. 1953. *Agra Univ. J. Res.* (Sci.), 2 (2) : 247, pl. viii.

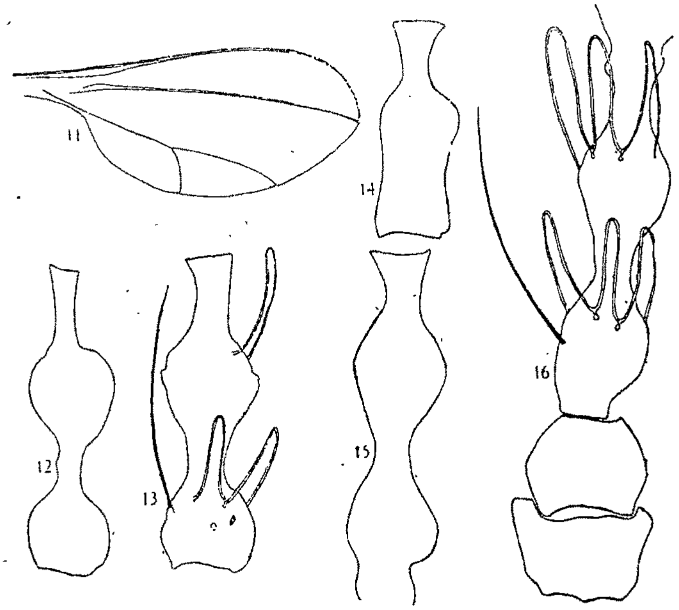


Schizomyia cocculi, sp. nov. 5. Palpus of female. 6. Basal antennal segments of female. 7. Terminal antennal segments of male. 8. Terminal antennal segments of female. 9. Palpus of male. 10. Wing of male.

been reared from the same gall; this is perhaps either a contamination or possibly an inquiline.

Contarinia inouyei, sp. nov.

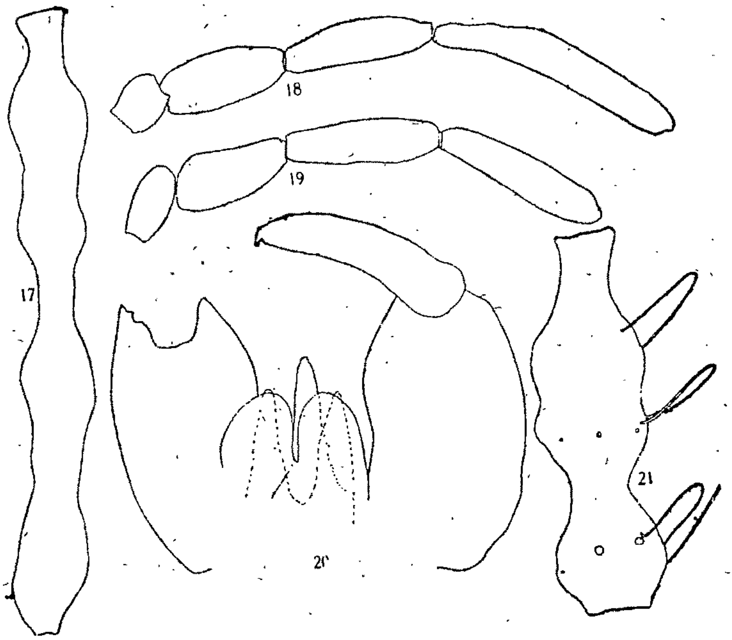
Male.—Length 0.5—0.75 mm. General colour in specimens preserved in spirit brown. Palpus (Fig. 18) quadriarticulate; first palpal segment short, oval; second segment stouter than first, about three times as long as thick; third segment more slender than the second, about five times as long as thick, somewhat longer than the second segment; fourth segment slender, longer than the rest of the palpal segments, nearly seven times as long as thick and about one and two-fifths the third segment. Antennae (Fig. 12, 13, 15, 16,) longer than body, with 14 segments; scape somewhat wider than long; pedicel about two-thirds as long as wide; third and fourth antennal segments fused together; third antennal segment with an apical stem about one-sixth the length of the segment; fourth antennal segment about five-sixths the length of third, with apical stem about one-fifth the length of the segment; fifth antennal segment equal to the fourth, with basal enlargement subglobose, apical enlargement globose, basal enlargement with a diameter about one and a half times its length, basal stem slightly longer than thick, apical enlargement as long as thick, apical stem nearly equal to the diameter of the apical enlargement and about three times as long as thick; sixth to eighth segments each nearly equal to the fifth segment; ninth segment slightly shorter than the preceding and with distinctly more slender stems; tenth antennal segment somewhat shorter than ninth and with basal stem nearly twice as long as thick, apical stem about three times as long as thick; eleventh and twelfth segments subequal, with stems more slender than that



Contarinia inouyei, sp. nov. 11. Wing of male. 12. Eleventh antennal segment male. 13. Fifth antennal segment, male. 14. Fifth antennal segment, female. 15. Fourth antennal segment, male. 16. Basal antennal segments, male.

of the tenth segment. Mesonotum brown. Wing as in fig. 11. Metatarsus one-fifth the second tarsal segment; third tarsal segment nearly four times the metatarsus; fourth segment somewhat more than one half the length of the third segment; fifth tarsal segment nearly twice the metatarsus. Claw simple on all legs, slender, slightly curved, shorter than empodium. Abdomen brown. Dorsal plate of genitalia (Fig. 20) deeply bilobed, the lobes ovate, rounded apically. Ventral plate equal to dorsal plate, more deeply and broadly bilobed, the lobes narrow, emarginate, triangular. Style moderately stout, slightly longer than dorsal plate. Basal clasp segment moderately stout, simple. Terminal clasp segment slender, about one half the basal clasp segment, unidentate apically.

Female.—Length 1.0—1.25 mm. General colour of body in material preserved in spirit yellowish-brown. Palpus (Fig. 9) quadriarticulate; first palpal segment subglobose; second segment stout, nearly twice as long as thick; third segment nearly three times as long as thick, about one and one-fourth the second segment; fourth palpal segment more slender and nearly equal to the third



Figs. 17-20. *Contarinia inouyei*, sp. nov. 17. Basal antennal segments, female. 18. Palpus male. 19. Palpus, female. 20. Male genitalia. 21. *Aschistonyx abietis*, sp. nov. fourth antennal segment, male.

segment. Antennae (Fig. 14, 17) slightly shorter than body, with 14 segments ; third and fourth antennal segments fused together ; third segment about five times as long as thick, with stem nearly as long as thick and about one-tenth the length of the segment ; fourth antennal segment a little more than three-fourths the length of third segment, with stem about one-fourth the length of the segment ; fifth antennal segment slightly shorter than fourth segment, with stem nearly one-third the length of the segment ; eighth antennal segment with stem nearly one-third the length of segment and nearly three times as long as thick. Mesonotum dark brown. Metatarsus nearly one-sixth the second tarsal segment ; third tarsal segment slightly less than half the second; fourth segment about two-thirds the third; fifth segment slightly longer than metatarsus. Claw as in male. Ovipositor exserted, long, nearly half the length of body.

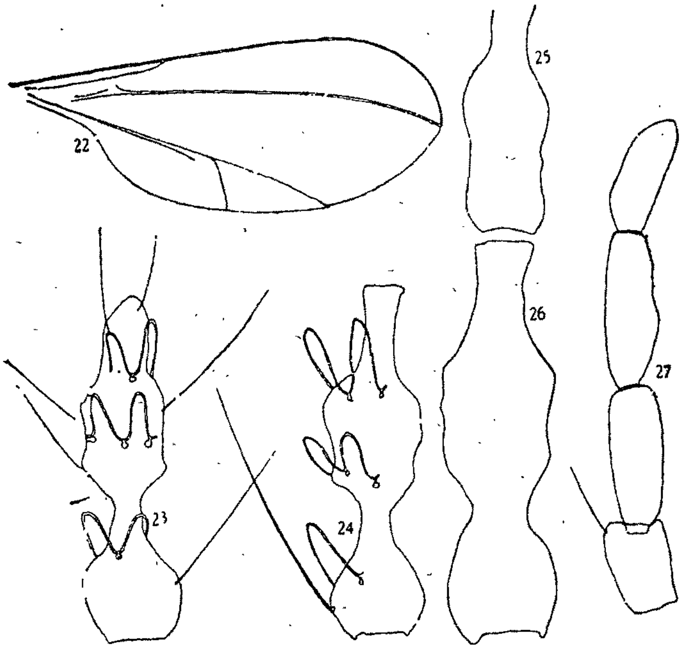
Holotype one male, *allotype* one female dissected on slides, *paratypes* males and females on slides and in spirit, in the collections of the Zoological Survey of India, Indian Museum, Calcutta ; *paratypes* in spirit in the collections of the Sapporo Branch of the Forest Experiment Station, Japan. Received from Dr. Motonori Inouye, Entomologist, The Sapporo Branch of the Government Forest Experiment Station, Toyohira, Sapporo, Hokkaido : Japan, labelled : "Reared from needle-leaf gall on *Cryptomeria japanica* D. Don. (sugi), specimen No. 1, Kagoshima: Kyushu : Japan, Coll. M. Inouye, 1-iv-1953."

I have great pleasure in associating with this species the name of Dr. Motonori Inouye.

Aschistonyx abietis, sp. nov.

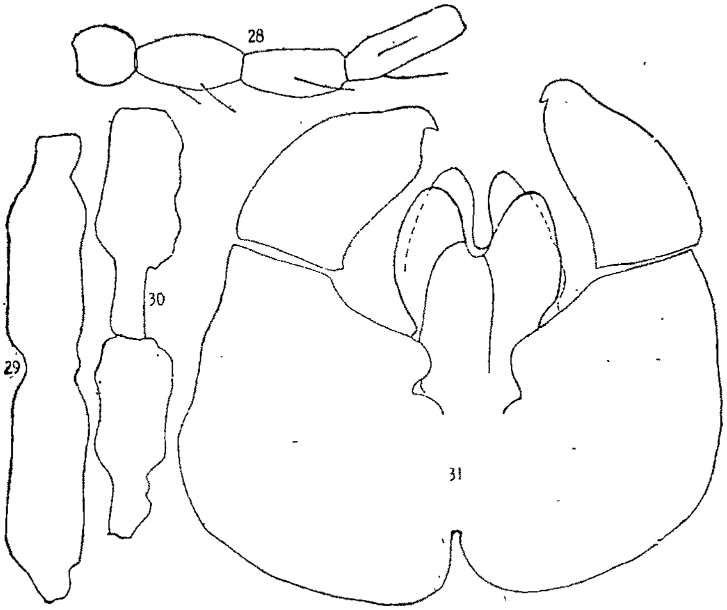
Male.—Length 1.75—2.0 mm. General Colour in Specimens preserved in spirit yellow. Palpus (Fig. 27) quadriarticulate, moderately long; first palpal segment short, stout, with a length about one and a half times the thickness; second palpal segment somewhat more slender, one and one-fourth the first and nearly twice as long as thick; third palpal segment very slightly longer than second, but nearly as thick; fourth palpal segment about one and a half times the length of third. Antennae (Fig. 21, 23, 24, 26) as long as body, with 14 segments;

third and fourth antennal segments fused together, each nearly equal; third segment subcylindrical, with three distinct nodes and apical stem about one-fifth the length of the segment; fourth antennal segment with the basal enlargement subglobose, strongly constricted off from the apical subcylindrical enlargement, which has as a slight constriction before the middle, apical stem equal to that of the third segment ; fifth antennal segment slightly longer than fourth, basal enlargement subglobose, basal stem very short, apical enlargement constricted in the middle, with a length nearly one and a half times the diameter of the basal enlargement, apical stem with a length about twice its diameter and nearly one-fourth the length of the segment; segments 6 to 9 subequal to fifth segment; eighth segment with apical stem nearly three times as long as thick but equal to that of the preceding segment; basal stem of ninth segment as long as thick, apical stem nearly three times the diameter; tenth segment somewhat shorter than ninth, basal stem as long as thick, apical stem about three- fourths the apical enlargement and



Aschistonyx abietis, sp. nov. 22. Wing. 23. Fourteenth antennal segment, male. 24. Thirteenth antennal segment, male. 25. Fifth antennal segment, female. 26, Fifth antennal segment, male. 27. Palpus, male.

three times as long as thick; eleventh segment equal to tenth; twelfth segment slightly shorter and nearly equal to the fourth antennal segment, apical stem equal to apical enlargement; thirteenth antennal segment somewhat shorter than twelfth, with apical stem nearly twice the basal stem, equal to the apical enlargement and nearly about twice as long as its thickness; fourteenth segment about two-thirds the fifth antennal segment and somewhat shorter than thirteenth, with basal enlargement globose, apical enlargement oval and ending in an obtuse short, stout, conical process. Wing as in fig. 22. Metatarsus one-fifth the second tarsal segment; third segment about half the second; fourth tarsal segment about three-fourths the third : fifth tarsal segment equal to metatarsus. Claw slender, slightly curved, simple, slightly shorter than empodium. Abdomen about half the length of body. Dorsal plate of genitalia (Fig. 31) deeply bilobed, the lobes oval, broadly rounded apically. Ventral plate very slightly shorter than dorsal plate, broadly and deeply bilobed, the lobes broadly rounded apically. Basal clasp segment short, stout. Terminal clasp segment short, moderately stout, with a conspicuous curved tooth apically. Style stout, shorter than dorsal and ventral plates.



Aschistonyx abietis, sp. nov. 28. Palpus, female. 29. Third and fourth antennal segments, female. 30. Terminal antennal segments, female. 31. Male genitalia.

Female.—Length 2.75-3.0 mm. excluding ovipositor. General colour of body in material preserved in spirit yellow. Palpus quadriarticulate ; first palpal segment ovate, a little longer than thick, stout, short; second palpal segment three times as long as thick; third palpal segment nearly equal to the second; fourth palpal segment one and one-fourth the third and more slender. Antennae (Fig. 25, 29, 30) less than half the length of body, with 14 segments; third and fourth antennal segments; fused together; fourth antennal segment with a stem nearly as long as thick; fifth antennal segment with stem about two-sevenths the length of the segment and twice its own thickness, the enlargement nearly twice as long as thick; segments 6 to 8 each equal to the fifth antennal segment; ninth segment somewhat shorter; tenth segment slightly shorter than ninth, with stem about one-third the length of the segment and distinctly more slender than that of fifth antennal segment; segments 11 to 12 each nearly equal to tenth; thirteenth antennal segment distinctly shorter than twelfth; fourteenth antennal segment slightly longer than thirteenth and apically with an obtusely rounded stout process about one-fourth the segment. Metatarsus about one-fourth the second tarsal segment; third tarsal segment slightly less than half the second; fourth segment about two-thirds the third; fifth segment nearly equal to metatarsus. Claw as in male. Ovipositor about one-third the length of body, with lamellae short, orbicular.

Holotype one male, *allotype* one female and *paratypes* males and females dissected on slides; *paratypes* males and females also in spirit. Holotypes, allotypes and part of the paratypes in the collections of the Zoological Survey of India, Indian Museum, Calcutta; the remaining paratypes in the collections of the Forest Experiment Station, Sapporo, Japan. Received from Dr. Motonori Inouye, Entomologist, The Sapporo Branch of the Government Forest Experiment Station, Toyohira, Sapporo, Hokkaido: Japan, labelled: "Reared from needle-leaf gall on *Abies mayriana*, specimen No. 3, Miyabo & Kudo, Coll. Motonori Inouye, 2. vi. 1953."

I take this opportunity of thanking Mr. S. Ramchandran. Retired Government Entomologist, Coimbatore, South India and Dr. Motonori Inouye, Entomologist, Japanese Government Forest Experiment Station, Sapporo, Hokkaido, Japan, for placing these specimens at my disposal.

DESCRIPTIONS OF SOME NEW CHALCIDS (PARASITIC HYMENOPTERA) FROM INDIA*

By CHANDY KURIAN, M. Sc., F. R. E. S., *Research Associate, School of Entomology, St. John's College, Agra.*

The type specimens of the new species described here are for the time being retained in the collection of School of Entomology. I thank Dr. M. S. Mani, Professor of Zoology and Entomology, for placing this material at my disposal and for guidance.

Superfamily CHALCIDOIDEA

Family EURYTOMIDAE

Tribe Eurotomini

Eurytoma tatipakensis, sp. nov.

Female.—Length 2.1 mm. Colour brownish-black. Head black; viewed from above length slightly less than one-third the width; interorbital distance three-fifths the width of the head; post-orbital space very slightly less than one-third the width of eye; ocelli reddish-brown, arranged in a broad triangle; interocellar distance thrice the ocellocular, which latter is four-fifths the front ocellar; vertex distinctly roughly rugosely punctate, with short, stiff, silvery-brown birstles; viewed in front length three-fourths the width of the head; interorbital distance somewhat less than three-fourths the width of the head; post-orbital one-seventh the length of eye, which latter is twice the length of gena; eyes dark brown, bare. Frons and face rugosely sculptured, punctures broad and irregular, covered over by silvery-white pubescence; clypeus truncate; mandibles dark reddish-brown; scrobes deep and distinct, stopping at a little away from the anterior ocellus. Antenna inserted on the middle of face, above an imaginary line joining the lower orbital borders; reddish-brown, with short, somewhat

---

*Contribution No. 39 from the School of Entomology, St. John's College, Agra, published with the permission of the Professor of Zoology and Entomology.

thick, silvery-white pubescence; 10-segmented; scape, pedicel, one ring joint, five segmented funicle and two jointed club; scape thrice the pedicel; pedicel five times the ring joint; first funicular half the scape and one and a half times the pedicel; second and remaining funicular segments gradually become shorter until the last funicular is two-fifths the scape and is equal to pedicel and ring joint combined; first joint of club equal to pedicel; second slightly less than twice the first; both the club joints together very slightly less than the scape. (Fig. 4 and 5).

Thorax : Length one and two-thirds the width at the region of the tegulae; pronotum anteriorly narrowing into a sort of neck, posteriorly nearly as broad as mesonotum, anterior region transversely coriaceously sculptured, posteriorly rugosely sculptured; punctae large and deep, with short, silvery-white pubescence; mesonotum very slightly longer than pronotum, sculpture same as the latter; parapsidal furrows deep and complete; mesopleura divided by a carina into two areas, anterior area smooth, posterior rugosoreticulately sculptured; scutellum one and one-fourth the mesonotum, sculpture same as that of the latter; metanotum nearly covered over by the backwardly projecting scutellum, nearly smooth and shiny; propodeum slightly less than the scutellum, depressed medially, with a median longitudinal carina anteriorly, which disappear posteriorly, nearly smooth and shiny except for faint irregularly reticulate sculpture; laterally rugosely sculptured, with silvery-white pubescence; propodeal spiracles small and oval. Legs reddish-brown; coxae darker and nearly of the same colour as the body. Hind coxa thrice the trochanter; femur nearly one and a half times the coxa and trochanter combined; tibia somewhat longer than the femur; tibial spurs larger one-sixth the tibia and smaller half the larger; metatarsus one-fourth the tibia and half the rest of tarsi combined (Fig. 3). Fore wing length slightly over twice the breadth; submarginal four times the marginal, which latter is equal to post-marginal; stigmal three-fourths the post-marginal (Fig. 1 & 2). Abdomen five-sixths the thorax, somewhat laterally compressed; five tergites visible; first tergite subequal to fourth and much larger than the rest; second and third tergites slightly less than half the fourth; fifth the smallest; ovipositor well exserted, from its apex up to the base of the ovipositor sheath nearly one-fifth the whole length of abdomen, including the sheath ploughshare-shaped.

Holotype female dissected on slide No. $\frac{943}{C}$ (a); paratype female on pin No. $\frac{943}{C}$ labelled : "Parasites on *Natada nararia*, Tatipaka, 4-iv-53, Coll. A. B. Rao."

This species runs close to *Eurytoma pallidiscapus* Cameron, from which it differs in having colour brownish-black, with short, stiff, silvery-brown bristles; vertex distinctly, roughly and rugosely punctate; mesonotum rugosely sculptured, without a long, smooth, shiny, triangular space; propodeum with a single median longitudinal carina and stigmal vein being only three-fourths the post-marginal.

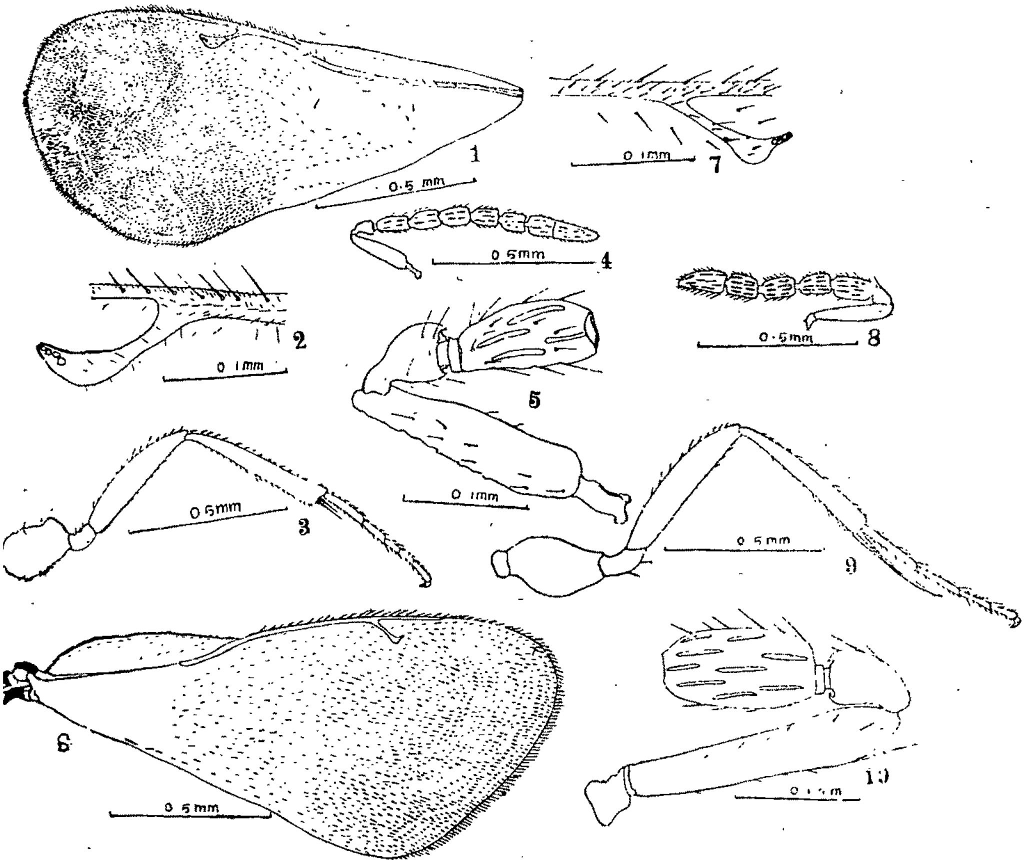


FIG. 1-5. *Eurytoma tatipakensis*, sp. nov. female 1. fore wing, 2. stigma of fore wing enlarged, 3. hind leg, 4. antenna, 5. basal segments of antenna enlarged.

FIG. 6-10. *Euplectromorpha natadae*, sp. nov. male 6. fore wing, 7. stigma of fore wing enlarged, 8. antenna, 9. hind leg, 10. basal segments of antenna enlarged.

Family ELACHERTIDAE

Subfamily Euplectrinae

Euplectromorpha natadae, sp. nov.

Male.—Length 1.8 mm. Colour black, with very faint metallic lustre in the abdomen. Head black; viewed from above transverse, length slightly less than one-third the width of the head; interorbital distance four-ninths the width of the head; post-orbital distance obsolete; vertex smooth and shiny, with a few scattered silvery-white setae; ocelli prominent, dark reddish-brown to black, arranged in a broad triangle; interocellar distance twice the ocellocular, which latter is one and a half times the front ocellar; viewed in front length nearly five-sixths the width; inter-orbital distance five-ninths the width of the head; length of eye slightly over twice the gena and seven times the post-orbital length; frons and face smooth and shiny, with very few short, silvery-white setae, mostly arranged along the orbital border; clypeus slightly convex, smooth and shiny; mandibles black; scrobes deep, broad, run up to nearly the front ocellus. Antenna inserted just above an imaginary line joining the lower orbital borders; brown , except reddish-brown scape, which is lighter in colour than the rest of antenna, covered over by a somewhat thick growth of short, silvery-white pubescence; 8-segmented; scape, pedicel, one ring joint, four segmented funicle and entire club; scape three and three-fourths the pedicel; ring joint one-fifth the pedicel; first funicular four-sevenths the scape and slightly over twice the pedicel; second funicular slightly over three-fourths the first; third and fourth subequal to second and half the scape; club very slightly less than two-thirds the scape and two-thirds the last two funicular segments combined; rest of details and setation as in fig. 8 & 10.

Thorax : Black, length slightly over one and one-third the width; pronotum short, narrow, margined in front, irregularly transversely rugosely striate, with few, short, scattered, silvery-white pubescence and two long, silvery-white setae, one on either side; mesonotum nearly twice the pronotum, rugosoreticulate, with few, shallow, broad punctae, pubescence as in pronotum, but setae longer posteriorly; paraspsidal furrows somewhat distinct and complete; scutellum as long as mesonotum, densely rugosely punctate, almost flat, lateral furrows distinct and crenulated, transverse furrow distinct, broad and somewhat arched; metanotum one-fourth the scutellum, faintly irregularly sculptured; propodeum three-fourths the scutellum, together with the metathorax equal to scutellum, oblique, very faintly sculptured, nearly smooth and shiny, with a median longitudinal carina running up to the posterior end; propodeal spiracles large, elongate-oval. Legs reddish-brown, coxae concolouress with the body. Hind coxa twice the trochanter; femur somewhat longer than coxa and trochanter combined; tibia very slightly longer than the femur; tibial spurs very long, longer nearly two-thirds the tibia and equal to metatarsus and the next tarsus combined; smaller very slightly over half the latter and slightly less than the metatarsus; rest of tarsi combined slightly over one and a half the metatarsus (Fig. 9). Fore wing length nearly two and one-fourth the breadth; submarginal long, one and three-sevenths the marginal; postmarginal nearly two-thirds the marginal; stigmal very slightly more than one-third the post-marginal (Fig. 6 &7). Abdomen black, with a faint metallic red lustre in certain angles, short, two-thirds the thorax, dorso-ventrally flattened, apically nearly truncate; petiolate, petiole short, broader than long or subquadrate; five tergites visible; first the largest; tergites smooth and shiny, except for few scattered setae mostly arranged on the sides and apex.

Holotype male partly dissected on slide No. $\frac{941\ (b)}{C}$ and rest in spirit labelled : "Parasitic on *Natada*, Tatipaka, 20-iii-1953, Coll. K. B. Rao"; paratype male dissected on slide No. $\frac{943\ (b)}{C}$ labelled : "Parasitic on *Natada nararia*, Tatipaka, 4-iv-1953, Coll. A. B. Rao."

This species runs close to *Euplectromorpha malayensis* Ferr., from which it differs in having the lateral furrows of scutellum crenulated.

Family ENTEDONTIDAE

Subfamily Omphalinae

Secodes narariae, sp. nov.

Female.—Length 2.8 mm. Colour yellowish-brown to reddish-brown. Head yellowish-brown. Viewed from above length slightly less than half the width; interorbital distance very slightly more than five-ninths the width of the head; post-orbital very little or nearly obsolete; width of eye nearly ten times the post-orbital distance; vertex yellowish-brown, emarginate, nearly smooth and shiny, sparsely covered over by brown setae; ocelli arranged on a raised area, prominent, brown, with a red tinge; interocellar distance one and one-half the ocellocular, which latter is one and a half times the front ocellar; viewed in front length somewhat less than three-fourths the width; interorbital distance somewhat more than half the width of the head; post-orbital nearly obsolete; length of eye nearly twice that of gena; eyes brownish-black, sparsely pubescent; frons and face yellowish-brown, smooth and shiny; sparsely covered over by pubescence of the same colour; clypeus slightly browner than the cheeks which latter has the same colour as the face, nearly rounded at apex; mandibles and palpi yellowish-brown; cheek concolouress with face; scrobes indistinct. Antenna brown, covered over by brown pubescence, inserted below the middle of face, on or slightly above an imaginary line joining the lower orbital borders; 10-segmented; scape, pedicel, four segmented funicle and triarticulate club; scape thrice the pedicel, with four long setae somewhat apically arranged; pedicel has five long setae, the anterio-dorsal one the largest; ring joint one-fourth the pedicel; first funicular slightly less than twice the pedicel and ring joint combined; second funicular six-sevenths the first; third and fourth gradually become shorter; first club joint two-fifths the last funicular; second equal to first; third very slightly longer than the preceding; all club joints together nearly three-fourths the scape and three-fifths the last two funicular joints combined (Fig. 14 & 16). Thorax : yellowish-brown, length one and two-thirds the width at the region of the tegulae; pronotum much narrower than mesonotum, anteriorly somewhat rounded, transversely rugosely striate, with two long silvery-brown setae, posterio-laterally one on either side; mesonotum slightly less than twice the pronotum, irregularly rugosocoriaceously sculptured, with silvery-brown setae, eight of which are large, four medially, two on either side, one behind the other, four posteriorly, two on either side; parapsidal furrows distinct and complete; scutellum very slightly longer than mesonotum, sculpture same as latter; axillae well defined, nearly meeting in the middle, but not confluent, with four long setae concolouress with that in the mesonotum; metathorax faintly irregularly sculptured, nearly smooth and shiny; propodeum reddish-brown, shiny, with a median longitudinal carina, which joins the basal carina posteriorly, anteriorly bifurcates, runs sideways and joins the lateral carina enclosing two spaces on either side of the median longitudinal carina; propodeal spiracles large, lanceolate-oval. Legs light yellowish-brown. Mid legs as in fig. 15. Hind coxa two and a half times the trochanter; femur four times the trochanter and one and one-seventh the coxa and trochanter combined; tibia slightly smaller than femur; tibial spurs long, longer spur two-thirds the tibia, twice the metatarsus and somewhat longer than metatarsus and first tarsus combined; smaller spur nearly

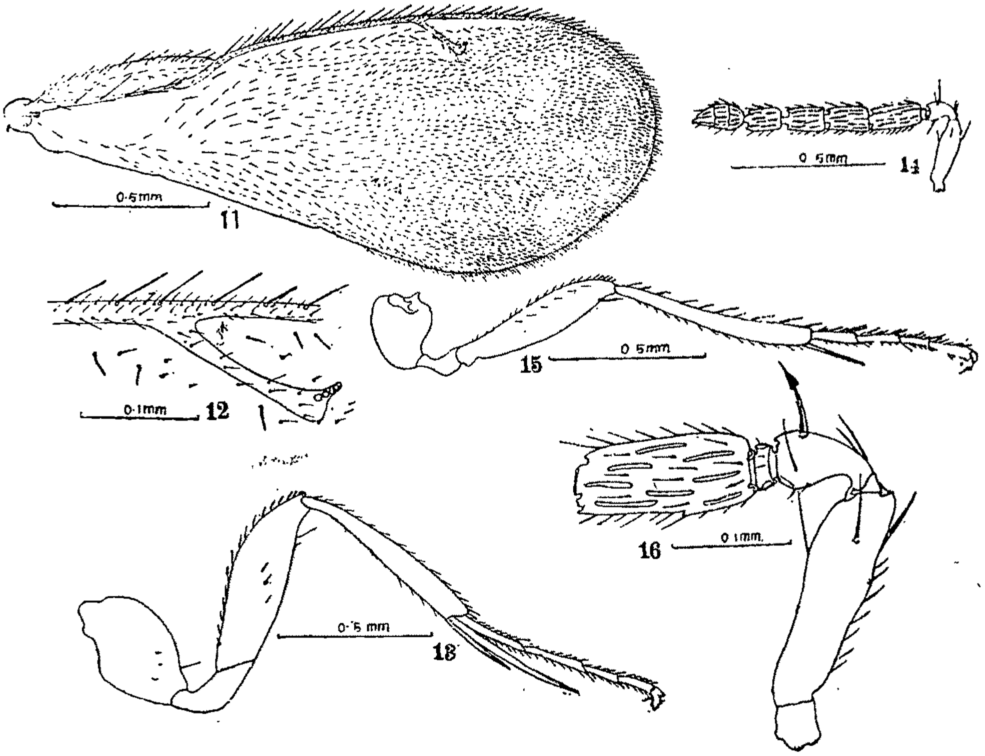


FIG. 11-16. *Secodes narariae*, sp. nov. female 11. fore wing, 12. stigma of fore wing enlarged, 13. hind leg, 14. antenna, 15. mid leg, 16. basal segments of antenna enlarged.

two-thirds the larger; metatarsus one-third the tibia and slightly longer than half the rest of tarsi combined; metatarsus and the rest of tarsi combined being slightly longer than the tibia (Fig. 13). Fore wing length two and two-fifths the breadth; submarginal seven-eighths the marginal, which latter is slightly less than twice the post-marginal; stigmal half the post-marginal; rest of details and pubescence as in fig. 11 & 12. Abdomen reddish-brown, apically darker; lanceolate-oval, posterior somewhat pointed, dorsally depressed, concavity beginning after the basal one-fourth; seven tergites distinctly visible; tergites smooth and shiny, with few setae; first, second and sixth tergites longer than the rest; ovipositor not much exserted; ovipositor-sheath ventrally given off from the base of the last tergite.

Holotype female dissected on slide No. 944/C; paratype 1 female in spirit labelled: "Parasites on *Natada nararia* larvae, Appanapalli, 20-iii-1953, Coll. K. B. Rao". This is the first record of the genus from India.

Euderus natadae, sp. nov.

Female.—Length 1.5 mm. Colour reddish-brown. Head viewed from above length one-third the breadth; interorbital distance two-thirds the width of the head; post-orbital distance very short, only one-sixth the width of eye; ocelli dark reddish-brown, arranged in a broad triangle in a raised area on the vertex; interocellar space one and one-fourth the ocellocular which latter is twice the front ocellar; eyes dark reddish-brown, covered over by short, spiny, silvery-white hairs; vertex faintly coriaceously striate or nearly smooth and shiny, with few, scattered, long setae; viewed in front length two-thirds the width; interorbital distance very slightly less than two-thirds the width of the head; length of eye one and a half times that of gena; clypeus slightly convex, apically smooth and rounded; mandibles yellowish-brown; palpi light brown. Antenna inserted below the middle of the face, on an imaginary line joining the lower orbital borders; brown, except for lighter scape and pedicel; 10-segmented; scape, pedicel, ring joint, four segmented funicle and indistinctly triarticulate club; scape slightly less than two and a half times the pedicel; ring joint one-fifth the pedicel; first funicular very slightly longer than, or as long as the pedicel; second subequal to the first; rest of the funicular segments gradually become shorter, until the last funicular is slightly more than one-third the scape and a little less than the pedicel; club joints together two-thirds the scape and somewhat less than the last two funicular segments combined (Fig. 19 & 20).

Thorax : Reddish-brown; length slightly less than one and a half times the breadth; pronotum as long as mesonotum; anteriorly somewhat transversely carinate, faintly irregularly coriaceously sculptured, with six brownish-black setae posteriorly placed, three on either side; mesonotum rugosely coriaceously sculptured; parapsidal furrows distinct and complete; in the area bounded by the parapsidal furrows are six setae, four medium sized, brown, anteriorly placed and two long black setae posteriorly disposed; lateral to parapsidal furrows are posteriorly arranged four long black setae, two on either side; scutellum larger than mesonotum, coriaceously sculptured, with four long black setae, two anteriorly and two posteriorly placed; metathorax slightly less than one-third the scutellum, nearly smooth and shiny; propodeum somewhat longer than metathorax, with two longitudinal carinae meeting the transverse basal carina, enclosing a small rectangular area; propodeal spiracles small and round. Legs brown. Hind coxa two and a half times the trochanter, which latter is one-third the femur, tibia equal to femur; tibial spurs long, longer spur three-fifths the tibia and somewhat less than metatarsus and first tarsus combined, smaller half the larger; metatarsus two-fifths the tibia and slightly less than two-thirds the rest of tarsi combined (Fig. 21). Fore wing length two and one-third the breadth; submarginal very slightly more than four-fifths the marginal; post-marginal somewhat less than half the marginal and slightly less than twice the stigmal (Fig. 17 & 18). Abdomen three-fourths the thorax; reddish-brown, darker than the thorax, more so at the sides; dorso-ventrally somewhat flattened, broadly oval, apically somewhat conical; petiolate, petiole short, broader than long, quadrate; five tergites visible, tergites smooth and shiny, except for few setae mostly disposed laterally; first and second tergites much longer than the rest and cover nearly two-thirds of the whole of abdomen.

Holotype female dissected on slide No. 942/C(a), labelled : "parasitic on *Natada nararia*, Tatipaka, 20-iii-1953, Coll. K. B. Rao"; paratypes 3 females, one 942/C(a) with the same label and two 942/C(b), one dissected on slide No. 942/C(b) and another on pin labelled : "parasitic on *Natada nararia*, Tatipaka, 4-iv-1953, Coll. A. B. Rao".

This species approaches *Euderus lividus* (Ashmead), but is readily distinguished by reddish-brown colour; knee of legs white; funicular joints much longer than broad; stigmal being only slightly more than half the post-marginal and ovipositor being not much exserted.

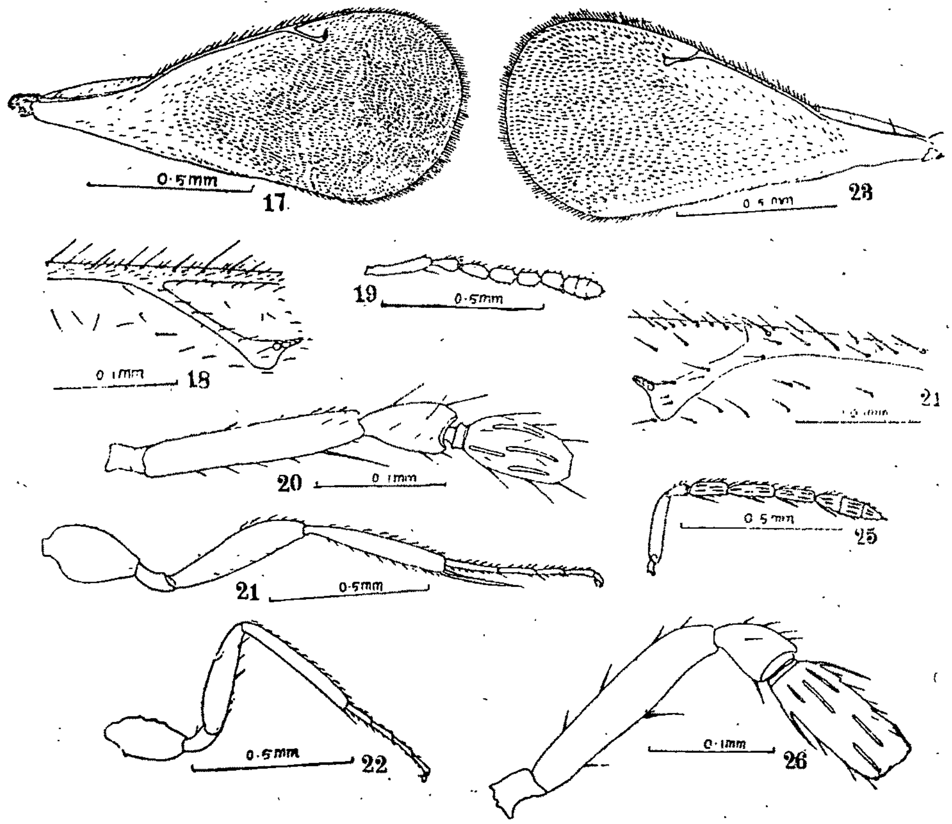


FIG. 17-21. *Euderus natadae*, sp. nov. female 17. fore wing, 18. stigma of fore wing enlarged, 19. antenna, 20. basal segments of antenna enlarged, 21. hind leg.

FIG. 22-26. *Aprostocetus epilachnae*, sp. nov. female 22. hind leg, 23. fore wing, 24. stigma of fore wing enlarged, 25. antenna, 26. basal segments of antenna enlarged.

Family TETRASTICHIDAE

Subfamily Tetrastichinae

Aprostocetus epilachnae, sp. nov.

Female.—Length 1.75 mm. Colour black, with metallic-green lustre. Head black, with metallic-green lustre, having a golden tinge; viewed from above width four times the length; interorbital distance somewhat more than half the width of the head; post-orbital distance very little or nil; eyes brownish-black, with few short pubescence; vertex irregularly rugosocoriaceously sculptured, emarginate; ocelli same colour as the eyes, arranged in a broad triangle; interocellar space twice the ocellocular, which latter is about one and a half times the front ocellar; viewed in front length five-sixths the width; interorbital distance about three-fifths the width of the head; length of gena two-thirds that of eye, with a faint line running from below the orbit, upto the mouth; post-orbital space about one-fifth the length of eye; frons and face faintly rugosocoriaceously sculptured; scrobes moderately deep and complete; face with two ridges running from laterally to the base of antenna up to just above the clypeus; clypeus nearly truncate; antenna brown, except lighter scape and pedicel, covered over by silvery-brown pubescence; 9-segmented; scape, pedicel, one ring joint, three segmented funicle and triarticulate club; scape thrice the pedicel ; ring joint nearly one-sixth the pedicel; first funicular one and three-fourths the pedicel; second slightly more than the first; third subequal to the first; first club joint about two-thirds the last funicular, rest gradually become shorter, terminal with a short nipple-like process towards the apex; all club joints together somewhat longer than the scape and six-sevenths the last two funicular segments combined (Fig. 25 & 26).

Thorax : Black, with a metallic-green lustre; length nearly one and a half times the width at the region of the tegula; pronotum short, rugosely sculptured; mesonotum two and a half times the pronotum, longitudinally rugosocoriaceously sculptured; parapsidal furrows distinct, deep and complete; median longitudinal furrow present, more distinct posteriorly; metanotum short, faintly irregularly sculptured; scutellum equal to mesonotum, sculpture same as the latter, with two lateral longitudinal grooves and two broad foveae on either side; propodeum half the scutellum, irregularly rugosely sculptured with a leathery appearance, with the median longitudinal carina running posteriorly and diverging as the basal carina, which joins the very thick lateral carina enclosing two areas on either side. Legs honey-brown, except coxa, trochanter and femur excluding the knee, which are concolouress with the body; hind coxa two and a half times the trochanter; femur nearly four times the trochanter and somewhat more than the coxa and trochanter combined; tibia one and one-sixth the femur; tibial spur one-seventh the tibia and two-thirds the metatarsus; metatarsus very slightly more than one-fourth the tibia and slightly less than half the rest of tarsi combined (Fig. 22). Fore wing length slightly more than twice the breadth; submarginal very slightly less than the marginal, which is nearly four times the stigmal; post-marginal absent; rest of details and pubescence as in fig. 23 & 24. Abdomen metallic bluish-green; one and one-fourth the thorax; dorsally depressed; six tergites visible, first the largest, rest of them subequal; tergites smooth and shiny, with few scattered silvery-brown pubescence; ovipositor not much exserted.

Holotype female dissected on slide No. 941/C(a); paratype one female in spirit, labelled :"parasitic on *Epilachna* grubs, Razol, 20-iv-1953, Coll. A. B. Rao".

This species approaches *A. coorgensis* Kurian,* but is readily distinguished by having mesonotum black with a metallic-green lustre; propodeum irregularly rugosely sculptured with a leathery appearance; first funicular being one and three-fourths the pedicel and marginal very slightly longer than the submarginal.

KEY TO SPECIES**

1. Interocellar space about twice or slightly over twice the ocellocular..................2
   Interocellar space thrice or more than thrice the ocellocular..............................3

---

*Kurian, C. 1952 *Agra Univ. J. Res.*, **1** : 59-60.

**Key to species described from India previously to include the newly discovered form.

2. Reddish-brown to black specimens; scape less than twice the pedicel............*israeli* Mani & Kurian.
Metallic-blue or green specimens; scape more than twice the pedicel..................4

3. Mesonotum metallic-blue; propodeum with a fine leathery sculpture; fore wing length two and one-third the breadth; club very slightly longer than the two preceding funicular segments combined..............................*punjabensis* Kurian

Mesonotum metallic-green; propodeum rugoso-punctate; fore wing length somewhat more than twice the width; club nearly equal to the last two funicular segments combined...*nowsherensis* Kurian

4. Scape twice or more than twice the pedicel..5
Scape less than two and a half times the pedicel...6

5. Mesonotum metallic-blue, with a greenish-tinge; propodeum finely longitudinally coriaceously striate; first funicular segment nearly twice the pedicel; marginal slightly shorter than the submarginal..........................*coorgensis*. Kurian

Mesonotum black, with a metallic-green lustre; propodeum irregularly rugosely sculptured with leathery appearance; first funicular one and three-fourths the pedicel; marginal slightly shorter than the submarginal........*epilachnae*, sp. nov

6. Propodeum finely rugosely sculptured, about one and a half times the thorax *krishnieri* Mani
Propodeum rugoso-reticulately sculptured, abdomen slightly longer than the thorax...*asphondyliae* Mani & Kurian.

Family TETRASTICHIDAE

Subfamily Tetrastichinae

Syntomosphyrum israeli, sp. nov.

Female.—Length : 1.5 mm. Colour : Dark reddish-brown to black with a metallic green or blue hue in different parts of the body. Head black, with a metallic blue lustre. Viewed from above transverse, thrice as broad as long; interorbital distance very slightly over two-thirds the width of the head; vertex indistinctly shagreened, emarginate, with few scattered silvery-white pubeseence; ocelli prominent, reddish-brown, arranged in a broad triangle; interocellar distance one and a half times the ocellocular, which latter is one and one-third the front ocellar; eyes reddish-brown, bare; viewed in front nearly round; interorbital distance very slightly less than two thirds the width of head; length of gena slightly more than half that of the eyes; face slightly convex, smooth and shiny; clypeus brown; mandibles reddish-brown, tridentate; antennae inserted slightly above the middle of face: scrobes distinct, separate and not reaching anterior ocellus; scape nearly reaching the front ocellus; brown except for yellowish-brown scape; 9-segmented; scape, pedicel, one ring joint, three-segmented funicle and triarticulate club; scape slightly less than four times as long as broad, slightly over two and a half times the pedicel; ring joint one-eighth the pedicel; first funicular segment nearly twice the pedicel; second and third funicular segments subequal to the first; first joint of club three-fourths the last funicular; second nearly five-sixths the first club joint; terminal very slightly over half the second, with a nipple-like process towards the apex; all the club joints together seven-eighths the scape, pedicel and ring joint combined; rest of details and setation as in fig. 29 & 30. Thorax : Pronotum short, narrow, finely indistinctly shagreened; mesonotum longitudinally coriaceously sculpturerd, much broader than pronotum with very distinct and deep paapsidal furrows and faint median furrow which is somewhat distinct towards the posterior end; tegulae yellow; axillae triangularly extending into the region of the tegulae, scutellum sculpture same as mesonotum divided by two parallel grooves into three areas; propodeum short, rugosely sculptured, with a median longitudinal carina, which bifurcates posteriorly and runs as basal carina; mesopleura impressed, divided by a longitudinal carina, the upper area being indistinctly transversely striate. Legs yellowish-brown. Hind coxa dorsaly black, trochanter more than half the coxa, femur nearly two and a half times coxa, tibia one and one-fourth the femur: tarsi four-segmented, all tarsal joints together slightly over three-fourths the tibia, claw simple (Fig. 31). Fore wing length slightly less than two and a half times the breadth; submarginal slightly more than the marginal; marginal with twelve strong setae; stigmal one-fourth the marginal; post-marginal absent; rest of details and pubescence as in fig. 27 & 28. Abdomen one and a half times as long as the thorax, laterally somewhat compressed; seven tergites visible, the first the largest, the rest gradually become shorter, the last small and conical; ovipositor long, exserted from ventrally far ahead of the abdominal tip.

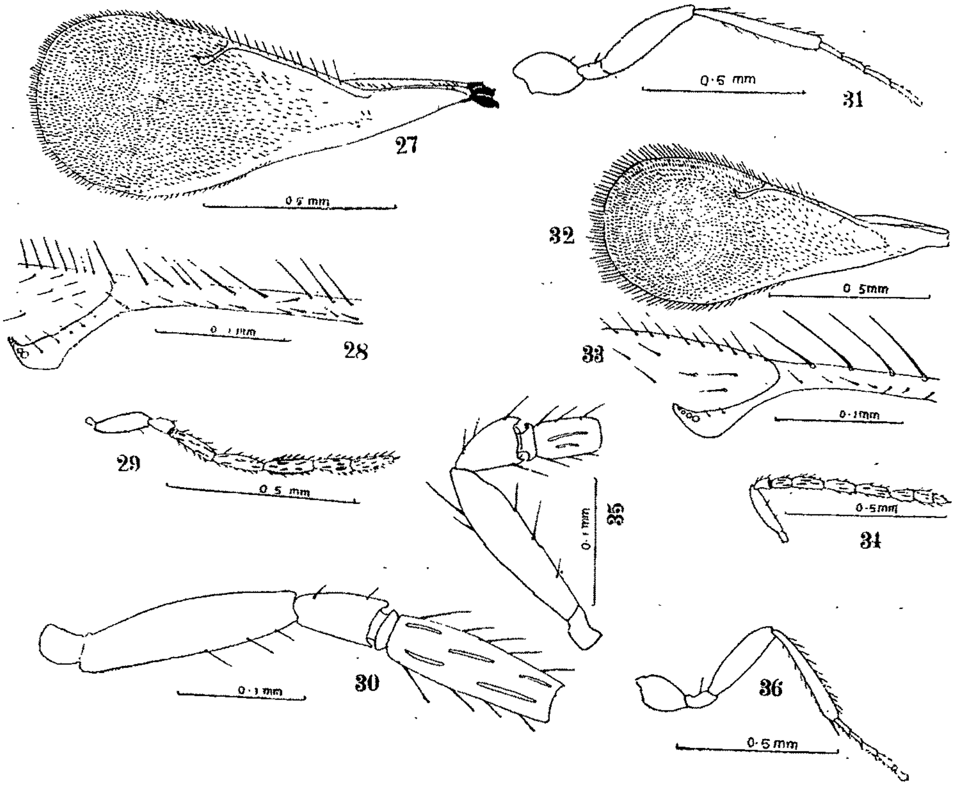


FIG. 27-31. *Syntomosphyrum israeli*, sp. nov. female 27. fore wing, 28. stigma of fore wing enlarged 29. antenna, 30. basal segments of antenna enlarged, 31. hind leg.

FIG. 32-36. *Syntomosphyrum israeli*, sp. nov. male 32. fore wing, 33. stigma of fore wing enlarged, 34. antenna, 35. basal segments of antenna enlarged, 36. hind leg.

Male.—Length : 1.2 mm. Colour : Reddish-brown with metallic green, blue, red or golden lustre. Head reddish-brown to black, with metallic green lustre and with golden and reddish hues in certain angles. Viewed from above length slightly over one-fourth the breadth; interorbital distance very slightly over three-fifths the breadth of the head; eyes reddish-brown; post-orbital space very short; ocelli reddish-brown, arranged in a broad triangle; interocellar distance nearly thrice the front ocellar, which latter is nearly two-thirds the ocellocular; viewed in front length nearly four-fifths the breadth; interorbital distance slightly over three-fifths the width of the head; gena more than half the length of the eye; antenna inserted just above the lower orbital border, nearly on the middle of face; brown, covered with brown, medium sized hairs; 10-segmented; scape, pedicel, one ring joint, 4-segmented funicle and triarticulate club; scape thrice the pedicel which latter is very slightly longer than the first funicular and very slightly shorter than the ring joint and first funicular combined; second funicular slightly less than twice the first and more than half the scape; third and fourth being subequal to the second; club joints gradually become shorter, altogether slightly longer than the scape; apex of antenna with a nipple-like process; rest of details and setation as in fig. 34 & 35. Thorax : Metallic green with a golden tinge in certain angles; length one and one-third the breadth; pronotum one-sixth the whole length of the thorax; finely rugosocoriaceously sculptured; mesonotum twice the pronotum, finely longitudinally coriaceously striate; parapsidal furrows deep and complete; scutellum as long as mesonotum, sculpture same as that of mesonotum, two lateral longitudinal grooves divide it into three areas one median and two lateral; metathorax one-fifth the scutellum; propodeum half the scutellum, rugosely sculptured; median longitudinal carina which bifurcates opsteriorly and runs as basal carina; propodeal spiracles nearly round; legs yellowish-brown except dark reddish-brown base of coxa; hind coxa twice the trochanter, femur equal to coxa and trochanter combined; tibia one and one-third the femur; tibial spur one-sixth the tibia and equal to metatarsus, the rest of tarsi combined being equal to thrice the metatarsus (Fig. 36). Fore wing length two and one-fourth the breadth; submarginal slightly longer than the marginal, which latter is thrice the stigmal; spot-marginal absent, rest of details and pubescence as in fig. 32 & 33. Abdomen very slightly longer than thorax; tergites smooth and shiny with very few scattered setae; five tergites visible, first the largest, second, third and fourth being subequal, fifth the smallest; male genitalia well exserted, with the sheath nearly two-thirds the abdomen.

Holotype female dissected on slide No. 175/C; *allotype* male dissected on slide No. 175/C; *paratypes* many males and females in spirit labelled as : "Ex. eggs of *Schoenobius*, C. R. R. I., Cuttack, 25-iv-1950, Coll. P. Israel".

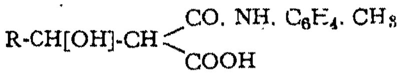
This species runs close to *Syntomosphyrum taprobanes* Waterston, from which it differs in having antenna brown; pedicel very slightly over one-third the scape; second segment of abdomen shorter than third; apical one-fourth of ovipositor serrate; hind tarsi with joint one slightly longer than two.

CONDENSATION OF 5-BROMO-VANILLIN, 5-BROMO-VERATRALDEHYDE, 6-BROMO-PIPERONAL AND 6-NITRO-PIPERONAL WITH MALON-O-TOLUIDIC ACID

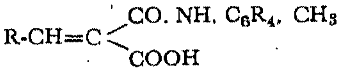
By M. C. Chaco and P. I. Ittyerah, *Chemistry Department, St. John's College, Agra.*

The condensation of vanillin, veratraldehyde and piperonal with malonanilic acid and with malon-*o*-toluidic acid has been reported by Ittyerah and Pandya (3,4). The same authors have reported the condensation of 5-bromo-vanillin, 5-bromo-veratraldehyde, 6-bromo-piperonal and 6-nitro-piperonal with malonanilic acid. (5) Therefore the work embodied in this paper affords a good opportunity for studying the influence of substituent groups such as bromo or nitro on the reactivity of the -CHO group in an aromatic aldehyde. It has been pointed out that the difference in the activity of vanillin, veratraldehyde and piperonal is the result of the different types of groups present on the aromatic ring of these aldehydes.

Three products may be expected from the condensation of an aromatic aldehyde with malon-*o*-toluidic acid. They are :

[a] 

$$\text{R-CH[OH]-CH}\left\langle\begin{matrix}\text{CO. NH. C}_6\text{H}_4\text{. CH}_3\\ \text{COOH}\end{matrix}\right.$$

[b] 

$$\text{R-CH=C}\left\langle\begin{matrix}\text{CO. NH. C}_6\text{R}_4\text{. CH}_3\\ \text{COOH}\end{matrix}\right.$$

[c] $\text{R-CH=CH-CO. NH. C}_6\text{H}_4\text{. CH}_3$

where R = an aryl radical.

No product of the type (a) has been isolated in these reactions. Types (b) and (c) are stable and have been isolated. Thus 5-bromo-veratraldehyde, 6-bromo-piperonal and 6-nitro-piperonal gave the corresponding benzylidene-malon-*o*-toluidic acids and the corresponding cinnam-*o*-toluidides. 5-Bromo-vanillin gave only 5-bromo-4-hydroxy-3- methoxy-cinnam-*o*-toluidide.

The presence of a bromo group in the aldehyde molecule produced greater activity of the aldehyde group. Though no generalisation can be made easily, it may be concluded from the observations made during the experiments described in this paper that the presence of a bromo group has resulted in the production of a higher yield. Thus the yield of 5-bromo-3.4-dimethoxy-benzylidene-malon-*o*-toluidic acid was 43.2%, and that of 6-bromo-3.4-methylenedioxy-benzylidene-malon-*o*-toluidic acid was 75%, whereas in the condensation of veratraldehyde and piperonal with malon-*o*-toluidic acid only 41 % and 49.2 % respectively of the corresponding benzylidene-malon-*o*-toluidic acids could be obtained. (3) Similarly the presence of a nitro group in the aldehyde molecule has helped in giving a better yield. 6-Nitro-piperonal when condensed with malon-*o*-toluidic acid has given 74% yield of 6-nitro-3.4-methylenedioxy-benzylidene-malon-*o*-toluidic acid, whereas piperonal with malon-*o*-toluidic acid gave only 49.2% of 3.4-methylenedioxy-benzylidene-malon-*o*-toluidic acid. (3) Vanillin and its derivatives are the least reactive among the aldehydes mentioned.

Here a comparison may be made of the activating influence of the bromo and the nitro groups. 6-Nitro-piperonal and 6-bromo-piperonal provide a good example as the bromo and nitro groups occupy the same position on the aromatic ring of the aldehydes. 6-Bromo-piperonal on condensation with malon-*o*-toluidic acid gave 75% yield of 6-Bromo-3.4-methylene-dioxy-benzylidene-malon-*o*-toluidic acid, and 42.9% of 6-bromo-3.4-methylenedioxy-cinnam-*o*-toluidide. 6-Nitro--piperonal under the same conditions gave 74% of 6-nitro-3.4-methylenedioxy-benzylidene-malon-*o*-toluidic acid, and 39.8% of 6-nitro-3.4-methylenedioxy-cinnam-*o*-toluidide. It is evident that the two groups definitely activate the aldehyde group though there is not much difference when the groups are compared with each other.

Various conditions have been tried. Trace of pyridine or piperidine was used as condensing agent. Though these organic bases catalysed the reactions, they promoted the formation of resins also. This difficulty could be overcome by using a mixture of pyridine or piperidine with glacial acetic acid. Longer time of heating and variations in temperature helped in some cases to give better yields of products.

EXPERIMENTAL

Malon-*o*-toluidic acid was prepared from freshly distilled ethyl malonate and *o*-toluidine by the method described by Chattaway and Olmsted(1). The yield was about 45 per cent and the acid melted with decomposition at 143° C.

a. CONDENSATION WITH 6 NITRO-PIPERONAL

6-Nitro-piperonal was prepared by nitrating piperonal with nitric acid as described by Pandya and Varghese (6). Yield was almost quantitative and the product melted at 95.5° C.

1. *Without any condensing agent.* 1 gm. of malon-*o*-toluidic acid and 1 gm. of 6-nitro-piperonal were mixed and kept in a small round bottomed flask at 105-110° C for six hours. The dark product after cooling overnight was extracted with twice normal sodium hydroxide solution. The alkali extract on acidifying with strong hydrochloric acid did not give any precipitate. The residue was dried and then washed with benzene and recrystallised from alcohol. The product melted at 167° C. and weighed 0.67 gm. The crystals were white and needle shaped but changed to yellow on prolonged exposure. Found Nitrogen=8.57%: 6-nitro-3.4-methylenedioxy-cinnam-*o*-toluidide ($C_{17}H_{14}O_5N_2$) requires 8.59%.

2. *With glacial acetic acid.* 1 gm. each of the aldehyde and the acid were taken and 2 c.c. of acetic acid was added. This mixture was heated for six hours at 100°. The products were then extracted with twice normal sodium hydroxide solution. The residue was kept aside and the alkali extract was acidified with conc. HCl. A white precipitate was obtained which after repeated recrystallisation from alcohol melted with decomposition at 258°. It was sparingly soluble in benzene and ether but readily dissolved in acetone. It was identified to be 6-nitro-3.4-methylenedioxy-benzylidene malon-*o*-toluidic acid. Found Nitrogen = 7.89%: $C_{18}H_{14}O_7N_2$ requires 7. 55%.
Yield was 0.95 gm. (49.6%).

The residue kept aside was purified and this was identified to be 6-nitro-3.4-methylenedioxy-cinnam-*o*-toluidide. Yield was 0.25 gm. (15%).

3. *With a trace of pyridine and glacial acetic acid.* 1.5 gm. of malon-*o*-toluidic acid 1.5 gm. of 6-nitro-piperonal, 3 c.c. of acetic acid and 3 drops of pyridine were mixed and heated for 6 hours at 100°. On extraction in the usual manner 2.1 gm. (74%) of 6-nitro-3.4-methylenedioxy-benzylidene-malon-*o*-toluidic acid and 0.6 gm. (23%) 6-nitro-3.4-methylenedioxy-cinnam-*o*-toluidide were obtained.

When piperidine was used in place of pyridine a large amount of resinous matter was formed.

b. CONDENSATION OF 6-BROMO-PIPERONAL

6-Bromo-piperonal was prepared by the bromination of piperonal according to the method described by Parijs (7). Better yields were obtained when the mixture (after complete addition of bromine) was kept aside at room temperature for at least one hour. Recrystallisation from benzene using a hot water funnel was found to be advantageous for its purification. Yield was 71.7% and the melting point 129°.

1. *Without any condensing agent.* There was no reaction when equimolecular quantities of malon-*o*-toluidic acid and 6-Bromo-piperonal were mixed and heated at 100° for 5 hours.

2. *With glacial acetic acid.* 0.96 gm. (146%) of 6-Bromo-3.4-methylenedioxy-benzylidene malon-*o*-toluidic acid was obtained when 1 gm. of malon-*o*-toluidic acid, 1.2 gm. of 6-bromo-piperonal and 5 c.c of glacial acetic acid were mixed and heated at 100° for four hours. The acid melted with decomposition at 242°. Found Bromine = 19.39%: $C_{18}H_{14}O_5NBr$ requires 19.78%. Yield 0.96 gm. (46%.)

3. *With a mixture of piperidine and glacial acetic acid.* A mixture of 1.35 gm, of malon-*o*-toluidic acid, 1.8 gm. of 6-Bromo-piperonal, 6 c.c. of glacial acetic acid and 3 drops of piperidine was heated at 85° for eight hours. On extraction in the usual

manner 2.2 gm. (75%.) of 6-bromo-3.4-methylenedioxy-benzyidene malon-*o*-toluidic acid was obtained.

4. *With a mixture of pyridine and piperidine.* On heating for eight hours at 100° C. a mixture of 1 gm. of malon-*o*-toluidic acid, 1.2 gm. of the aldehyde 1 c.c. of pyridine and 0. 1 c.c. of piperidine and then extracting in the usual manner, 0.8 gm. (42. 9%) of 6-bromo-3.4-methylenedioxy cinnam-*o*-toluidide was obtained. This was purified by washing with benzene and then recrystallising from alcohol. It melted at 225° C.

Found Nitrogen=4.01%: $C_{17}H_{14}O_3NBr$ requires 3.88%.

5. *With a trace of pyridine or piperidine.* When a trace of pyridine was used 11.8% yield of 6-bromo-3.4-methylenedioxy-benzylidene-malon-*o*-toluidic acid and 23.7% yield of 6-bromo-3 .4-methylenedioxy-cinnam-*o*-toluidide were obtained. When a trace of piperidine was used only the non-acid product was obtained and the yield was 42%. The experimental conditions were the same as in the previous experiment.

c. CONDENSATION OF 5-BROMO-VANILLIN

5-Bromo-vanillin was prepared by bromination of vanillin in warm glacial acetic acid, as recommended by Dakin (2). It was recrystallised from alcohol. It melted at 164° and the yield was almost theoretical.

1. *Without any condensing agent.* Equimolecular quantities of malon-*o*-toluidic acid and 5-bromo-vanillin were taken and heated for five hours at 100°. No product was formed and the unreacted aldehyde was recovered.

2. *In presence of piperidine acetate.* 1 gm. of malon-*o*-toluidic acid and 1.2 gm. of 5-bromo-vanillin were mixed and to this two drops each of piperidine and glacial acetic acid were added and heated for four hours at 100°. There was copious evolution of carbon dioxide and the colour of the mass was orange red. On extraction no acid product was obtained. 0.15 gm. of a non-acid product was obtained which after recrystallisation from al-

cohol melted at 186°. It was identified to be 5-bromo-4-hydroxy-3-methoxy-cinnam-*o*-toluidide.

Found Bromine = 22.6%: $C_{17}H_{15}O_3NBr$ requires 22.08%.

3. *In presence of pyridine acetate.* The above experiment was repeated using pyridine in place of piperidine. 0.25 gm. (13.3%) of 5-bromo-4-hydroxy-3-methoxy-cinnam-*o*-toluidide obtained.

On extending the time of heating to 12 hrs. in a subsequent experiment, the yield improved to 33%.

d. CONDENSATION OF 5-BROMO-VERATRALDEHYDE

5-Bromo-veratraldehyde was prepared by methylating 5 bromo-vanillin using dimethyl sulphate.

1. *Without any condensing agent.* 1 gm. of malon-*o*-toluidic acid and 1.3 gm. of the aldehyde were mixed and heated at 100° C for four hours. On extraction an acid product was obtained which after recrystallisation from alcohol melted with decomposition at 214° C. On exposure to air the white crystalline powder turned pale yellow. It was analysed and found to be 5-bromo-3.4-dimethoxy-benzylidene-malon-*o*-toluidic acid.

Found Bromine = 18.85%: $C_{19}H_{18}O_5NBr$ requires 19.03%.

2. *In presence of piperidine and glacial acetic acid.* By heating 0.5 gm. of malon-*o*-toluidic acid, 0.65 gm. of the aldehyde and two drops each of pyridine and acetic acid for 12 hrs. at 100° a brown mass was obtained. This on extraction gave a very small yield of 5-bromo-3.4-dimethoxy-benzylidene-malon-*o*-toluidic acid. A non-acid residue was left which could be crystallised from alcohol. This melted at 176° and weighed 0.3 gm. This was found to be 5-bromo-3.4-dimethoxy-cinnam-*o*-toluidide.

Found Bromine = 21.68%: $C_{18}H_{18}O_3NBr$ requires 21.26%. Yield 30.8%.

In another experiment when a larger proportion (1 mol.) of acetic acid and a trace of pyridine were used, the yield of the acid product rose to 42.2%. In the same experiment 15.4% yield of 5-bromo-3.4-dimethoxy-cinnam-*o*-toluidide also was obtained.

SUMMARY

Malon-*o*-toluidic acid was condensed with 6-nitropiperonal, 6-bromo piperonal, 5 bromo veratraldehyde and 5-bromo vanillin. With the first three aldehydes the corresponding arylidene malon-*o*-toluidic acids as well as the cinnam-*o*-toluidides were obtained depending on experimental conditions. With the last aldehyde however only the corresponding cinnam-*o*-toluidide was obtained. When an organic base like pyridine or piperidine was used as a condensing agent a good deal of resinous matter was formed but this could be in some cases minimised and in others prevented by using pyridine acetate or piperdine acetate instead of the free base.

REFERENCES

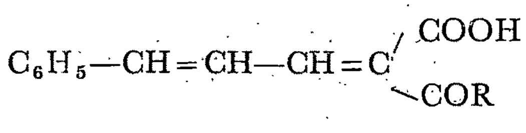
1. CHATTAWAY, F. D. and J. M. D. OLMSTED. 1910. *J. chem. Soc.*, **97** : 939.
2. DAKIN, H. D. 1909. *J. Am. chem. Soc.*, **42** : 477.
3. ITTYERAH, P. I. and K. C. Pandya. 1953. *Agra Univ. J. Res. (Sci.)*, **2** : 17.
4. ITTYERAH, P. I. and K. C. PANDYA. 1944. *Proc. nat. Acad. Sci. India.*, **14**. 95.
5. ITTYERAH, P. I. and K. C. PANDYA. 1944. *Proc. Indian Acad. Sci.*, (A)(**20**)(4) : 169.
6. PANDYA, K. C. and G. Varghese 1941. *ibid.* (A) **14** : 25.
7. PARIJS. 1929 *Am. chem. Abst.* 23 : 420.

CONDENSATION OF CINNAMALDEHYDE WITH MALONANILIC, MALON-*o*, *m*- and *p*-TOLUIDIC AND MALON-1.3.4.-XYLIDIC ACIDS

By P.P. BAGCHI and P. I. ITTYERAH, *Chemistry Department, St. John's College, Agra.*

The condensation of malonanilic acid with a large number of aromatic aldehydes has been reported earlier from this laboratory (4 to 9). In this journal the condensation of malon,-*o*-, *m*- and *p*-toluidic acids with vanillin, veratraldehyde and piperonal was reported (3). A few months ago the condensation of malon-1. 3. 4-xylidic acid with benzaldehyde, *m*-methylbenzaldehyde and *p*-methylbenzaldehyde was also reported (2). Attention has been drawn in these papers that in condensations of this type two products could be isolated. They are the corresponding benzylidene-malon-anilic, toluidic or xylidic acid and the corresponding cinnamanilide, toluidide or xylidide. The usefulness of a trace of an organic base like pyridine or piperidine as a condensing agent in these reactions also was pointed out.

This paper deals with the condensation of cinnamaldehyde with malonanilic acid, malon-*o*-toluidic acid, malon-*m*-toluidic acid, malon-*p*-toluidic acid and malon-1. 3. 4.-xylidic acid. Two products were expected in each case. (*a*) an acid product of the type



$$C_6H_5—CH=CH—CH=C\begin{matrix}/COOH\\ \diagdown COR\end{matrix}$$

and

(*b*) a non-acid product of the type

$$C_6H_5-CH=CH-CH=CH—COR$$

where R may be $-NHC_6H_5$ $-NHC_6H_4CH_3$, or $-NHC_6H_3(CH_3)_2$

Cinnamaldehyde behaved in a slightly different manner from other aldehydes in these reactions. Unlike most other aromatic aldehydes cinnamaldehyde gave only the acid product (*a*) The non-acid product (*b*) could not be isolated in any case. Whether the non-acid product was first formed and then decomposed is not known. An attempt to prepare the non-acid product (*b*) from the corresponding acid product (*a*) by decarboxylation was also not successful.

Another feature of these reactions was the formation of a lot of dark resinous matter. Even when the reactions were carried out in an inert atmosphere there was no decrease in the formation of resins.

As can be seen from Table II various condensing agents were tried. Traces of 2.4-lutidine was found to be the best condensing agent in these reactions.

Compared with other aromatic aldehydes cinnamaldehyde gave lower yields of the products. The maximum yield obtained in these reactions was only 53 per cent.

Malonanilc acid and malon-*o*-,*m*- and *p*-toluidic acids were prepared by the method described by Chattaway and Olmsted (1) and malon-1. 3. 4.-xylidic acid was prepared by the method described by Ittyerah and Chellppa (2).

EXPERIMENTAL

The general procedure has been to mix equimolecular quantities of the acid and cinnamaldehyde in a small round bottomed flask and to heat on a water bath for four hours at 80° C. In experiments in which a condensing agent was to be added it was added in traces (0.15 mol.). When glacial acetic acid was used as a condensing agent it was added in larger quantities (generally 1 mol.). After heating, the brown resinous mass obtained was extracted with normal sodium hydroxide solution. The alkali extract was then acidified with concentrated hydrochloric acid. A deep yellow product was precipitated. This was purified by recrystallisation from acetone. The purified product was analysed and its identity established.

Extraction of the product with normal solution of sodium hydroxide resulted in the formation of a larger quantity of tarry matter and consequent loss in the yield. So the method of extraction was slightly modified. The contents of the flask left after heating were washed with a little acidulated water to remove any organic base if present. The residue was then extracted with ether which dissolved all the resinous matter and any unreacted aldehyde. The yellow crystalline residue left was purified by recrystallisation from acetone.

All the products were bright yellow in colour and crystalline in nature. All melted with decomposition.

Table I gives the names of the new products obtained with their molecular formulae, melting points and nitrogen contents. Table II gives the conditions observed in each condensation.

TABLE I

No.	Name	Mol. Form	M. P.	Nitrogen Found	Nitrogen Calculated
1.	Cinnamylidene-malon-anilic acid	$C_{18}H_{15}O_3N$	206°	4.9	4.77
2.	Cinnamylidene-malon-*o*-toluidic acid	$C_{19}H_{17}O_3N$	195°	4.37	4.56
3.	Cinnamylidene-malon-*m*-toluidic acid	$C_{19}H_{17}O_3N$	200°	4.4	4.56
4.	Cinnamylidene-malon-*p*-toluidic acid	$C_{19}H_{17}O_3N$	221°	4.1	4.56
5.	Cinnamylidene-malon-1. 3. 4.-xylidic acid	$C_{20}H_{19}O_3N$	214°	4.7	4.33

TABLE II

Aldehyde	Acid	Condensing agent	Mol. Prop.	Temp.	Time	Yield
Cinnamaldehyde	Malonanilic acid	Nil	1 : 1	80 C	4 Hrs.	33
,,	,,	Pyridine	1 : 1 : 0.15	,,	,,	50
,,	,,	Triethanol amine	1:1:0.5	,,	,,	46
,,	,,	Pyridine acetate	1:1:0.15	,,	,,	51
,,	,,	Lutidine	1:1:0.15	,,	,,	53
,,	,,	Gl Acetic acid	1:1:1	,,	,,	30
,,	Malon-*o*-toluidic acid	Nil	1:1	,,	,,	33
,,	,,	Pyridine	1:1:0.15	,,	,,	43.3
,,	,,	Pyridine acetate	1:1:0.15	,,	,,	46.6
,,	,,	Lutidine	1:1:0.15	,,	,,	50
,,	,,	Gl Acetic acid	1:1:1	,,	,,	30

„	Malon-*m*-toluidic acid	Nil	1:1	80 C	4 Hrs.	17
„		Pyridine	1:1:0.15	„	„	23.9
„	„	Pyridine acetate	1:1:0.15	„	„	33
„	„	Lutidine	1:1:0.15	„	„	40
„	„	Gl Acetic acid	1:1:1	„	„	10
„	Malon-*p*-toluidic acid	Nil	1:1	„	„	20
„	„	Pyridine	1:1:0.15	„	„	26.6
„	„	Pyridine acetate	1:1:0.15	„	„	33.3
„	„	Lutidine	1:1:0.15	„	„	36.6
„	„	G l Acetic acid	1:1:1	„	„	13.3
„	Malon-1 3 4-xylidic acid	Nil	1:1	„	„	12.5
„	„	Pyridine	1 11:0.15	„	„	19
„	„	Pyridine acetate	11:0.15	„	„	31.3
„	„	Lutidine	1:1:0 15	„	„	40

SUMMARY

Cinnamaldehyde was condensed with malonanilic, malon-*o*-toluidic, malon-*m*-toludic, malon-*p*-toluidic and malon -1 3 4-xylidic acids It was found that a trace of 2.4-lutidine was the best condensing agent. The following compounds were prepared for the first time:—
Cinnamylidene-malonanilic acid, Cinnamylidene-malon-*o*-toludic acid, Coinnamylidene-malon-*m*-toluidic acid, Cinnamylidene-malon- *p*toluidic acid and Cinnamyledene-malon-1.3.4-xylidic acid They were all yellow in colour, crystalline in nature and melted with decomposition.

The author's thanks are due to the Uttar Pradesh Scientific Research Committee for the award of a Research Scholarship to one of them (P. P. B.), which has enabled him to take part in this work.

REFERENCES

1 CHATTAWAY F. D and J. M. D. OLMSTED 1910 1910. *J. chem. Soc.*, **97** : 939,
2 ITTYERAH P. I. and P. T. CHELLAPPAI 1953. *J. Indian chem. Soc.*, **30** : 6,387.
3 ITTYERAH P. I. and K. C. PANDYA 1953. *Agra Univ. J. Res.*, (*Sci*)., **2** : 17.
4 ITTYERAH P. I. and K. C. PANDYA 1914. *Proc. Indian Acad. Sci.*, **13** : 2;122.
5 ITTYERAH P. I. and K. C. PANDYA. 1941. *ibid.*, **13** : 2,119.
6. ITTYERAH P. I. and K. C. PANDYA. 1941. *ibide.*, **13** : 5,461.
7. ITTYERAH P. I. and K. C. PANDYA. 1944. *ibid.*, **20** : 4,169.
8. ITTYERAH P. I. and K. C. PANDYA. 1944, *Proc. National Acad. Sci. India.*, (A) **14**(2) : 9
9. PANDYA K. C. and (Miss) RASHMI BALA PANDYA. 1943. *Proc. Indian Acad. Sci.*, **17** : 1.

ROTATORY DISPERSION OF SOME SALTS OF REYCHLER'S ACID WITH DIVALENT METALS

By O. N. Perti, M. Sc., D. Phil., *Professor of Chemistry, Th. D. S. B. Government Degree College, Naini Tal.*

Recently a large number of molecularly asymmetric inorganic complexes have been investigated. For the resolution of such racemic complexes Reychler's acid has been very frequently employed. Study of optical rotations of its inorganic salts would throw much light on understanding the role of this acid in such resolutions. In this paper the rotatory dispersion in the visible region of some divalent metallic salts of Reychler's acid is discussed. The compounds referred to are magnesium, barium, strontium, calcium and zinc salts.

Experimental

Reychler's acid or D-camphor-β-sulphonic acid was prepared essentially by the method of Reychler (1). Pure natural D-camphor was sulphonated at room temperature by a mixture of acetic anhydride and concentrated sulphuric acid. It was purified by recrystallisation from alcohol and moisture-free ethyl acetate and dried in vacuum over anhydrous calcium chloride.

The magnesium, barium, strontium and calcium salts were prepared in a manner similar to those described by Graham (2). The details are given below.

Magnesium salt (3) : Reychler's acid (22.6 g.) was dissolved in distilled water (100 ml) and the solution was heated to boiling. Pure magnesium carbonate (3.79g.) was added to the hot solution in small quantities at a time. The whole was then boiled, filtered and the filtrate concentrated, when colourless crystals of magnesium salt separated. They were washed with a small amount (3 ml) of ice-cold water and dried in vacuum over anhydrous calcium chloride. Yield 19.95 g. (90%).

The substance has a high melting point of 239-240°. (4) It crystallises with six molecules of water of crystallisation. Magnesium in the salt was estimated as pyrophosphate. Found Mg—4.076%; $C_{20}H_{30}O_8S_2Mg.6H_2O$ requires Mg—4.092%.

Barium salt 5 : To D-camphor-β-sulphonic acid in aqueous solution was added excess of pure barium carbonate. The whole was boiled and then filtered. On concentrating the clear filtrate and cooling the concentrate in ice, crystals of barium salt separated. They were purified by recrystallisation from water. Yield of pure salt was 83%.

The crystals obtained in this manner contain water of crystallisation and get partly dehydrated when heated in an air oven. The salt was rendered completely anhydrous by keeping it at 130° in an air oven for ten hours. For the anhydrous salt—Found Ba = 22.87% : $C_{20}H_{30}O_8S_2Ba$ requires Ba = 22.92%.

Calcium salt (6) : 14.6 g. of Reychler's acid was dissolved in distilled water and was neutralised with excess of pure calcium carbonate. The solution was filtered and the filtrate concentrated to a small volume (20 ml). Alcohol was added to this concentrate and the solution was chilled when the salt crystallised out. It was purified by recrystallising it three times from aqueous alcohol. The anhydrous salt was obtained by heating the crystals at 110° in an air oven for 14 hours (7). Yield was 87.3%. For the anhydrous salt—Found S = 12.73% ; $C_{20}H_{30}O_8S_2Ca$ requires S = 12.76%.

Strontium salt (8) : This salt was obtained by a method analogous to that described for barium salt. It was purified by repeated recrystallisations from aqueous rectified spirit. The salt was made anhydrous by heating it at 125° in an air oven for 14 hours. Yield was 92%. For the anhydrous salt—Found S = 11.61% ; $C_{20}H_{30}O_8S_2Sr$ requires S = 11.65%.

All these salts (i. e. magnesium, barium, calcium and strontium) were found to be soluble in water, less soluble in rectified spirit, commercial methanol and pyridine but practically insoluble in absolute alcohol, benzene, acetone, carbon disulphide, ethyl acetate and ether.

It was also noticed that an hydrous calcium (9) strontium (8), and barium (5) salts fluoresced under the impact of X-rays. The intensity of fluorescence was in the order strontium salt>barium salt>calcium salt.

Zinc salt (10) : This salt had previously been prepared by Pope and Gibson by double decomposition between the barium salt of Reychler's acid and zinc sulphate. It was, however, found that a purer product is obtained if Reychler's acid is neutralised with slight excess of pure zinc carbonate, the solution filtered and the filtrate concentrated. The salt crystallises out in the form of lustrous prisms, m.p. 167°. This salt is readily soluble in water but is practically insoluble in pure anhydrous organic solvents. Found S=9.913% ; $C_{20}H_{30}0_8S_2Zn.6H_20$ requires S=10.09%.

The salt readily loses water of crystallisation on heating and at 130° becomes anhydrous. In other respects it is perfectly stable.

The rotatory dispersion measurements were carried out at room temperature employing Adam-Hilger Barfit polarimeter with slit and direct vision prisms. The light sources used are given in Table 1.

TABLE 1

THE LINES USED IN THE MEASUREMENT OF ROTATIONS.

	Light source	*Lines selected*
1.	Mercury vapour lamp	Hg4358, Hg5780, Hg5461
2.	Sodium vapour lamp	Na5893
3.	Neon lamp	Ne 6402
4.	Cadmium metal arc	Cd4678, Cd4800, Cd5086, Cd6438
5.	Zinc metal arc	Zn6362
6.	Lithium salt in carbon arc	Li6104, Li6708
7.	Barium salt in carbon arc	Ba6142, Ba6497

Values of specific rotations for different wavelengths are recorded in Table 2.

TABLE 2

OBSERVATIONS ON SPECIFIC ROTATIONS FOR DIFFERENT WAVELENGTHS OF LIGHT FOR AQUEOUS SOLUTIONS OF SALTS OF REYCHLER'S ACID

Salt of Reychler's acid	Magnesium salt	Barium salt	Calcium salt	Strontium salt	Zinc salt
Conc. in aqueous solution.	1·9459 g. in 100 ml	2·5043. in 100 ml	2.4888 g. in 100 ml	2·0176 g. in 100 ml	2·056 g. in 100 ml
Temperature in °C.	18	29	27	29	23
Wave length (λ)	Observed specific rotations $[\alpha]^{T}_{\lambda}$				
Pg4358	+66·30°	+54·09°	+76.12°	+68·66°	+89·73°
Cd4678	43·43	38·15	52·23	47·53	50·34
Cd4800	38·29	35·75	47·21	43·12	46·43
Cd5086	29·55	29·76	37·75	34·21	33·32
Hg5461	22·36	22·97	29·09	26·53	25·04
Hg5780	18·25	19.57	24·11	22·06	21·15
Na5893	17·22	18·58	22·90	20·82	19·45
Li6104	...	...	20·68	18·84	16·29
Ba6142	15·17	16·38	...	...	...
Zn6362	...	...	18·28	16·61	...
Ne6402	13·11	14·78	17·87	...	14·35
Cd6438	...	...	...	16·11	...
Ba6497	...	13·98	...	...	...
Li 6708	...	13·18	15·46	14·62	12·40

DISCUSSION

Analysis of the data recorded in Table 2 was carried out by the method suggested by Lowry (11). In each case a graph was plotted α against λ and it was found that in all cases α increases progressively as λ decreases and that the dispersion curve always remains convex towards the axis of wavelengths in the region 4358 to 6708. To find the nature of dispersion the reciprocal of the rotation ($1/\alpha$) was plotted against the square of wavelength (λ^2). It was found that in each case a straight line was obtained. This pointed to a simple dispersion in all cases in the region of transparency and that in this region the dispersion can be expressed by one term of Drude's equation, namely, $\alpha = \Sigma \frac{K}{\lambda^2 - \lambda_0^2}$ where K and λ_0 are constants (12). In each case the ratio $\alpha 4358/\alpha 5461$ was found to be greater than 1. 63 which confirmed the conclusion that the dispersion is simple in all cases.

Next, a rigorous algebraic analysis of the data was carried out and the constants K and λ_0 were calculated in each case. In Table 3 are recorded the calculated dispersion equations.

TABLE 3

THE CALCULATED DISPERSION EQUATIONS FOR SALTS OF REYCHLER'S ACID IN THE VISIBLE REGION.

Salts of Reychler's acid	K	λ_0	Dispersion equation
Magnesium salt	3·555	0·1392	$[\alpha]^{18}_{\lambda} = \frac{3{\cdot}555}{\lambda^2 - 0{\cdot}1392}$
Barium salt	4·585	0·09979	$^{29}_{\lambda} = \frac{4{\cdot}585}{\lambda^2 - 0{\cdot}09979}$
Calcium salt	5·273	0·1169	$[\alpha]^{27}_{\lambda} = \frac{5{\cdot}273}{\lambda^2 - 0{\cdot}1169}$
Strontium salt	4·831	0·1161	$[\alpha]^{29}_{\lambda} = \frac{4{\cdot}831}{\lambda^2 - 0{\cdot}1161}$
Zinc salt	3.755	0·1482	$[\alpha]^{23}_{\lambda} = \frac{3{\cdot}755}{\lambda^2 - {\cdot}1482}$

In Table 4 are given the differences between observed values of specific rotation and those calculated from the equations proposed in Table 3. To economise space both the observed and calculated values are given side by side and the differences are not shown separately.

TABEL 4

COMPARISON OF CALCULATED VALUES OF SPECIFIC ROTATION FROM PROPOSED DISPERSION EQUATION AND ACTUAL OBSERVATION FOR SALTS OF REYCHLER'S ACID.

(0)—Observed
(C)—Calculated

Wave length	Magnesium salt		Barium salt		Calcium salt		Strontium salt		Zinc salt	
	(O)	(C)	(O)	(C)	(O)	(C)	(O)	(C)	(O)	(C)
Hg 4358	66.30	69.97	54.09	50 84	76.12	72.13	68.66	65.37	89.73	89.82
Cd 4678	43.43	44.60	38.15	38.50	52.23	51.69	47.58	47.00	50.34	53.11
Cd 4800	38.29	38.97	35.75	35.13	47.21	46.45	43.12	42.27	46.43	45.67
Cd 5086	29.55	29.75	29.76	28.85	37.75	37.18	34.21	33.88	33.32	33.98
Hg 5461	22.36	22.36	22.97	23.11	29.09	29.08	26.53	26.53	25.04	25.03
Hg 5780	18.25	18.25	19.57	19.59	24.11	24.28	22.06	22.16	21.15	20.19
Na 4893	17.22	17.09	18.58	18.54	22.90	22.90	20.82	20.90	19.45	18.87
Li 6104	...	...	...	...	20.68	20.63	18.84	18.84	16.29	16.74
Ba 6142	15.17	14.94	16.38	16.53	...	...	...	...	...	...
Zn 6362	...	...	...	...	18.28	18.31	16.61	16.73	...	...
Ne 6402	13.11	13.13	14.78	14.79	17.87	17.99	...	...	14.35	14.35
Cd 6438	...	...	...	...	...	...	16.11	16.19	...	...
Ba 6497	...	...	13.98	14.22	...	...	...	...	...	...
Li 6708	...	...	13.18	13.09	15.46	15.83	14.62	14.46	12.40	12.45

From Table 4 it is quite clear that except for wave length Hg4358 the observed and calculated values are in good agreement. The rotation for the line Hg4358 in the violet region is difficult to read accurately.

CONCLUSION

From the data discussed in the previous section the following general conclusions can be arrived at.

All the salts examined, namely magnesium, barium, calcium, strontium and zinc salts of Reychler's acid exhibit simple dispersion in the region of transparency in the visible region.

In the case of alkaline earth salts the order of magnitude of rotation in the whole range of visible region is calcium salt > strontium salt > barium salt. The same order is obtained if the values of K (the absolute rotation) are compared.

The magnitude of rotation in the case of calcium, strontium and barium salts is in the reverse order of their atomic weights.

When rotations of magnesium and zinc salts are also taken into consideration it is found that, in general, the order of observed magnitude of rotation for different wave lengths of light used is calcium salt > strontium salt > barium salt > zinc salt > magnesium salt except in the violet-blue region. If, however, the values of K are compared this discrepancy disappears.

SUMMARY

The rotatory dispersion of salts of Reychler's acid with divalent metals—magnesium, barium, calcium, strontium, zinc—in the visible region in aqueous solution at room temerature is simple in nature. Further, in the case of alkaline earth salts, the magnitude of rotation is, in general, in the reverse order of the magnitude of their atomic weights.

REFERENCES

1. REYCHLER, 1898. *Bull. Soc. chem.*, **19**(3) : 120.
2. GRAHAM, 1912. *Trans. chem. Soc.*, **34** : 746.
3. PERTI, O. N. and MURTY, S. R K., 1952-53. *The Saugar Univ. J.* **1**(2) : 139.
4. BOZZOLA, 1937. *Chem. Ztbl.*, **11** : 2393.
5. PERTI, O. N. and MURTY, S. R.K.., 1952. *Curr. Sci.*, **21** : 194.
6. PERTI, O. N. and MURTY, S. R. K., 1953. *Proc. Indian Sci. Cong. Abs.*, 302.
7. POPE and GIBSON, 1910. *Trans. chem. Soc.*, **32** : 2214.
8. PERTI, O. N. and MURTY, S. R. K., 1953. *Proc. Indian Sci. Cong. Abs.*, 303.
9. NEW COMER, 920. *J. Amer. chem. Soc.*, **42** : 1997.
10. PERTI, O. N. and MURTY, S. R. K., 1953, *Curr. Sci*, (under publication).
11. LOWRY, T. M., 1935. Optical Rotatory Power, Chap. XXXII.
12. PERTI, O. N. and MURTY, S. R. K., 1951. *The Saugar Univ. J.*, **1**(1) : 151.

REDUCTION PROCESSES AT THE DROPPING MERCURY ELECTRODE IN PULSATING FIELDS: ZINC ION

By H. P. AGARWAL, Ph. D., A. R. I. C., *Assistant Professor of Chemistry, D. A. V. College, Kanpur.*

1. INTRODUCTION

Breyer and Gutmann (1) studied the behaviour of dropping mercury electrode in pulsating fields in systems involving the discharge of cadmium, thallium and zinc ions. All through their experiments a. c. field was confined to 50 cycles per sec. Doss and Agarwal (2) modified the technique and extended the measurements to frequencies from 12.5 to 600 cycles per sec. of the a. c. field. The present work relates to the study of reduction of zinc ions in pulsating fields.

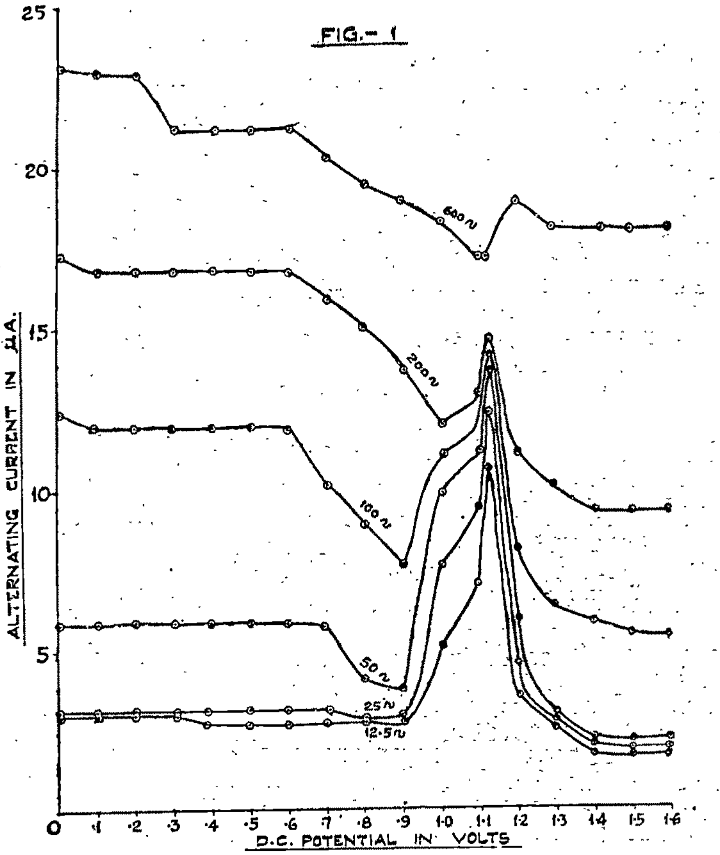
2. EXPERIMENTAL

The experimental arrangement and the characteristics of the dropping electrode are same as were used earlier (2). The experiment was performed with the molar potassium nitrate solution containing 2×10^{-3} M zinc ions (added in the form of zinc sulphate). The solution was freed from air by bubbling through it pure hydrogen from time to time. The alternating current at various frequencies, passing through the dropping electrode system at various d. c. potentials was measured and the results are given in Fig. 1. The readings for polarographic curve were taken simultaneously along with the above experiment. The polarographic curve is shown in Fig. 2.

3. DISCUSSION

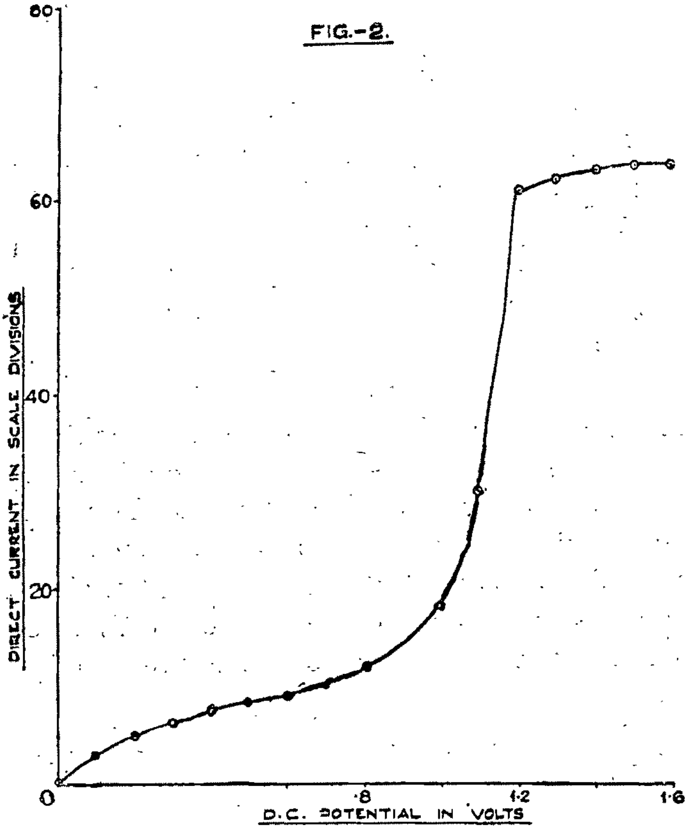
The half wave potential from polarographic curve (Fig. 2) taken simultaneously along with the observations by the Breyer-Gutmann technique, coincides, within the limits of experimental error, with the d. c. voltage corresponding to the Breyer-Gutmann maximum (hereafter referred to as B-G maximum) as can be seen from fig. 1. The value of the half-wave potential, 1.12 V, is with reference to the pool electrode and corresponds to 1.02 volt as referred to the saturated calomel electrode. The B. G. maximum occurs at nearly the same potential at all frequencies at which it occurs. The present case shows a behaviour corresponding to the system involving nickel ion (3) in which the B-G maximum persisted upto 50 cycles per second; whereas in the present case, the B-G maximum persists, however, upto 200 cycles per sec.

FIG.- 1



The above observations can be understood by a detailed consideration of the phenomenon. This can be done from two points of view, viz. the molecular kinetic and secondly the electrical equivalent of the dropping mercury electrode. In presence of a reducible ion, the large rise in a. c. current at the half wave potential indicates a diminution in the impedance of the dropping electrode system. This can be pictured as brought about by two parallel shunts *i. e.* a resistance and a capacity to the electric double layer at the mercury solution interface. The capacity shunt would have a high impedance for a slow reaction as in the case of nickel and zinc, where it would have a low impedance in the case of lead. With the present system, however, the total impedance comes out to be about 2300 ohms at the B-G maximum at 200 cyles per sec., out of which about 1600 ohms represents the external resistance inclusive of the cell resistance. The remaining 700 ohms would be accounted for by the cell reaction and the electrical double layer at the dropping mercury electrode. This shows, why a higher frequency dependence of the B-G current maximum is not observed with nickel and zinc.

FIG.-2.



The displacement of the B-G current maximum to lower values with lowering the frequency shows that the phenomenon can not be completely interpreted in terms of the simple electrical equivalents.

The molecular kinetic picture may next be taken up. At the half wave potential there are three important factors.

First we have the electrode process itself; secondly, we have the diffusion processes and thirdly the external resistance of the system.

It may be pointed out that the diffusion processes are more or less similar in all the systems studied as the diffusion coefficients are of the same order of magnitude. This factor would not, therefore, bring about material differences in the behaviour of the different systems. The external resistance in all the systems studied is kept the same, hence the main cause of the difference in behaviour appears to be the rate of electrode processes. This may vary several thousand fold in different systems (4). For instance thallium has rate constant of 1.5 units (moles per sq. cm. per sec. per mole per c.c.) whereas zinc with potassium nitrate as indifferent electrolyte has the value of 4.3×10^{-3}. Owing to the slowness of this electrode reaction, the electrode process is unable to keep pace with the a. c. field at high frequency which accounts for the disappearance of B.G maximum at high frequencies of the order of 600 cycles per sec. and over.

4. ACKNOWLEDGMENTS

My thanks are due to Dr. K. S. G. Doss, Professor of Sugar Chemistry, Indian Institute of Sugar Technology, Kanpur, for his continued interest and instructive discussions, Professor J. M. Saha, Director, Indian Institute of Sugar Technology, Kanpur and Professor K. P. Bhatnagar, Principal, D. A. V. College, Kanpur, for giving the necessary facilities to work and the U. P. Scientific Research Committee for a grant which made this work possible.

REFERENCES

1. BREYER, B. and F. GUTMANN. 1946. Electrode reductions in Alternating Fields III. The dynamic Capacitance, *Trans. Faraday Soc.*, (301), **43** (11 & 12) : 785.
2. DOSS, K. S. G. & H. P. AGARWAL. 1951. Reduction processes at he dropping mercury electrode in pulsating fields, *Proc. Indian. Acad. Sci.*, **33** : 66.
3. DOSS, K. S. G. & A. KALAYANASUNDARUM. 1951. Reduction processes at the dropping mercury electrode in pulsating fields : the nickle ion, *Proc. Indian Acad. Sci.*, **33** : 298.
4. RANDLES, J. E. B. 1947. Kinetics of Rapid electrode reactions, *Faraday Soc. Discussion*, (No. 1), p. 11.

COMPARATIVE STUDIES ON BUDDING AND GRAFTING IN LOQUAT, ERIOBOTRYS JAPONICA LIND.

By V. S. CHHONKAR, M. Sc., Ph. D., (Ohio) and M. K. SHARMA, M. Sc. (Ag.), *Government Agricultural College, Kanpur.*

The initial growth and the subsequent performance of a fruit plant is dependent to a great extent on the correct method of its propagation. At present the methods of propagation of fruit trees of known commercial value in India are those which have a comparatively higher percentage of success. In some other countries, which have developed horticultural practices through recent researches, the right method of propagating fruit trees is coming into prominence more rapidly, with an assurance of becoming the basis of a profitable industry. Lack of sufficient knowledge regarding the proper time and the type of vegetative propagation to be used with different fruit trees is probably one of the greatest hindrances in the quick development of fruit industry under conditions prevailing in India.

Loquat has been commonly propagated by seed, grafting or budding. There is very little specific information based upon well planned experiments, which might reveal the importance of various methods. There is no doubt that the seedlings of loquat and most cross-pollinated fruit trees do not reproduce true to the type and hence good varieties are perpetuated by budding or grafting (Fraser, 1924 and Firminger, 1930). Wright (1936) further believes that the plants raised from seeds take a long time in coming into bearing. Therefore budding or grafting seems to be a satisfactory mode of its propagation, provided it is done at the proper time and with sufficient care. Condit (1915) reported that good varieties of loquat should be propagated by budding and further mentioned that grafted plants need shelter from excessive sunlight. Based upon non-experimental observations, Singh (1937) believed that budding in loquat should be done twice a year, that is, (i) September-October (ii) January-February. Fraser (1924) however, recommended October and November as the proper budding time for Florida.

The above observations reveal that experimental evidence on the comparative merits of budding and grafting are scanty, and since both these methods seem to be in common vogue, it was decided to carry out investigations on the relative merits of two methods. This was done during the rains (July) and Spring (February) under field conditions at the Botanical Gardens, Government Agricultural College, Kanpur.

EXPERIMENTAL TECHNIQUE

Loquat trees put on new flush of growth during rains and spring and are apparently best suited for vegetative propagation at this time. In the present studies both budding and grafting were done on 50 plants during the months of July and February. The stocks practically uniform in growth were about 2 years old. Shield budding was done and every possible care was exercised in the proper selection of buds. They were taken from the well matured wood of the previous season's growth and were properly tied on selected stocks. Similarly, inarching was done at the height of 9″ from the ground level.

The plants raised by the above two methods during the two seasons were closely observed for comparative studies. Measurements of the plant height and the diameter of the main stem were taken at regular intervals for 16 months as detailed below.

Height of the plant.—All the plants were trained on a single stem and the height of the main stem was recorded in Cms at regular intervals of four weeks.

Diameter of stem.—Diameter of the main stem was recorded at a point 6″ above the ground level in each of the budded and grafted plants.

RESULTS

The observations recorded during the course of this investigation have revealed some interesting information with regard to the propagation of loquat plants. The type of graftage as well as the time when it is practised under field conditions are of considerable value in inducing the set and subsequent growth of the propagated plants as enumerated below.

Percentage of success.—It will be evident from Table I that grafting in February and July did not vary significantly and the difference was merely 4%. Budding in February was superior to that of July where the percentages of success were 76 and 56 respectively. Comparing the two methods, although grafting appeared to be slightly superior to budding in February, the difference failed to reach the significant level. However, in July budding was very much poorer and the percentage of success was significantly lower when compared with grafting in either of the two seasons or with the February budding. In other words, grafting is definitely superior to budding practised in the rainy season, but is not markedly so in February.

From the above results it appears that budding in February and grafting in July and February, which yield almost equal percentage of success, may be followed for further multiplication of plants.

The data when put to statistical analysis revealed the following differences in the percentage of success by the methods of propagation followed in July and February. (Table II).

This table clearly indicates the differences between February grafting vs. February budding, July grafting vs. February grafting and July grafting vs. February budding which were very meagre. On the other hand July grafting vs. July budding, July budding vs. February budding and February grafting vs. July budding revealed very significant differences and the ratio of difference to standard error of difference ranged from 4.0117 to 8.1703.

Height of the Plant.—Not only the percentage set but also the subsequent growth of plants were closely related to the type and time of propagation. A perusal of data portrait in Tables III and IV would clearly reveal the differences in average mean height of the plants. The mean height of the plant varies from 69.5 to

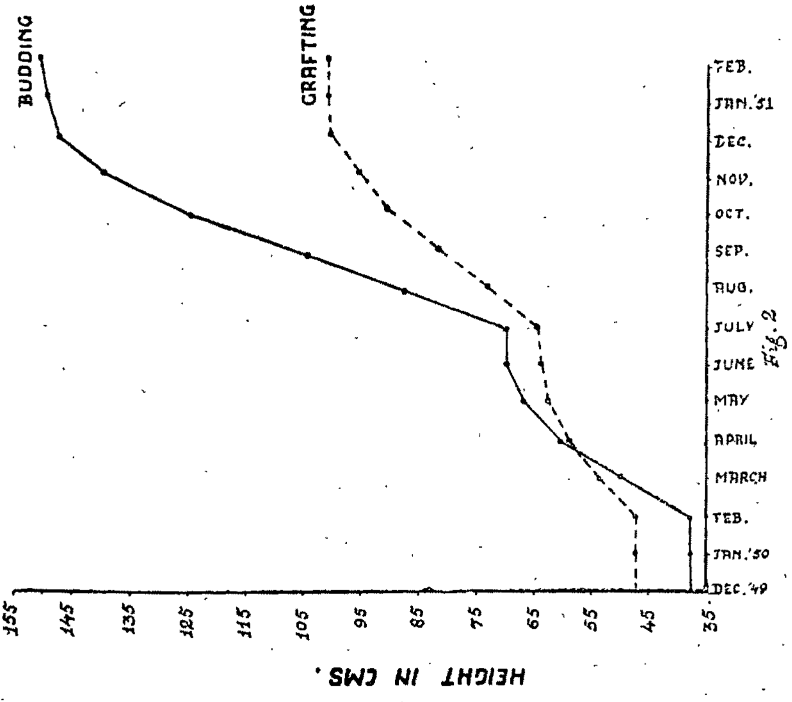


Fig. 1

MEAN RATE OF MONTHLY GROWTH IN HEIGHT OF PLANTS PROPAGATED IN JULY.

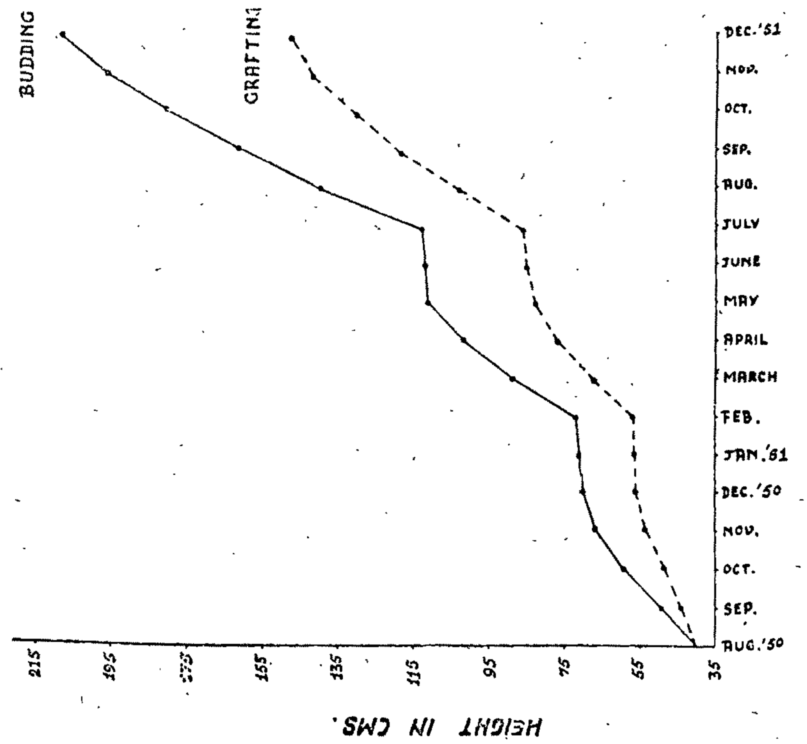


Fig. 2

SHOWING THE MEAN RATE OF MONTHLY GROWTH IN HEIGHT OF PLANTS PROPAGATED IN FEBRUARY

110.3 cms. Stem elongation in plants grafted in July was definitely poor, and significantly lower than that of the February grafting or July and February budding. Budding in February appears to be superior so far as the height of the plants is concerned. The differences between the mean height for July budded and February grafted plants was not significant and the heights recorded were 83.9 and 83.0 cms. respectively. For a detailed comparison of the mean height differences, the figures are given in Table IV.

Thus it could be very well concluded, that budding is superior to grafting as regards height when practised in any of the two seasons. Further grafting in February appears to be quite satisfactory when compared to that of July.

The results observed for the mean height per plant are further supported by the monthly mean height and average rate of growth per plant as shown in Figures 1 and 2 and Tables V and VI.

Monthly mean height.—The graphical representations of monthly mean height (Figures 1 and 2) clearly indicate the trend in main shoot elongation for the two methods of propagation during the two seasons. Budding when compared to grafting in February gives higher monthly mean height. The figures for budding and grafting in July are more or less alike till the month of July but subsequently the budded plants grew at a faster rate than the grafted ones.

Average rate of growth in height.—The average rate of growth in plants propagated by budding and grafting varied markedly during the course of this investigation. It is evident from Tables V and VI that the figures for average rate of growth are significantly higher for February budding when compared to July or February grafting. The second highest increase in rate of growth was observed in July budded plants and it was significantly higher when compared with plants grafted in February or July. February grafting induced a significantly higher rate of growth than July grafting.

Mere elongation of stem may not be a correct criterian for the various growths of plants unless there is a corresponding increase in the diameter of the main stem. Therefore the measurements of the diameter were also recorded for successful comparison of the two methods followed in the propagation of loquat.

Diameter of the stem.—Observations recorded for the diameter of the main stem are shown in Tables VII and VIII and the trend in the variation corresponds closely with that of height of the plants. The mean diameter for February budding was significantly higher when compared to February grafting, July budding and July grafting. The differences between mean diameter for February grafting and July budding were not significant but these were significantly higher than those for July grafting.

It is thus evident that budding seems to be definitely superior to grafting as regards diameter of the stem irrespective of the season, and both budding and as well as grafting in February are superior to grafting in July.

Monthly mean diameter.—The variations in the monthly mean diameter for budded and grafted plants at different times are shown in Figures 3 and 4 and it clears the measurements of February and July budded plants higher than those are for plants grafted during the major portion of the period of experimentation. The values were also higher for budding and grafting in February than those in July.

Average rate of growth in diameter.—The average rate of growth in diameter per plant propagated by budding and grafting is recorded in Tables IX and X. It would appear from these tables that the differences between budding in February and July were not significant. Nevertheless this rate of growth in diameter was significantly higher when compared to grafting done either in February or in July. It is further evident from the tables that the rate of growth in diameter for February grafting was significantly higher than that for July grafting. Further, no appreciable differences were observed in February or July budding.

From the above observations it could be very well concluded that budding is superior to grafting irrespective of the season as far as the increase in the height and diameter of the main stem is concerned. Grafting when done in the month of February is superior to that in July.

Fig. 3

MEAN RATE OF MONTHLY GROWTH IN DIAMETER OF PLANTS PROPAGATED IN JULY.

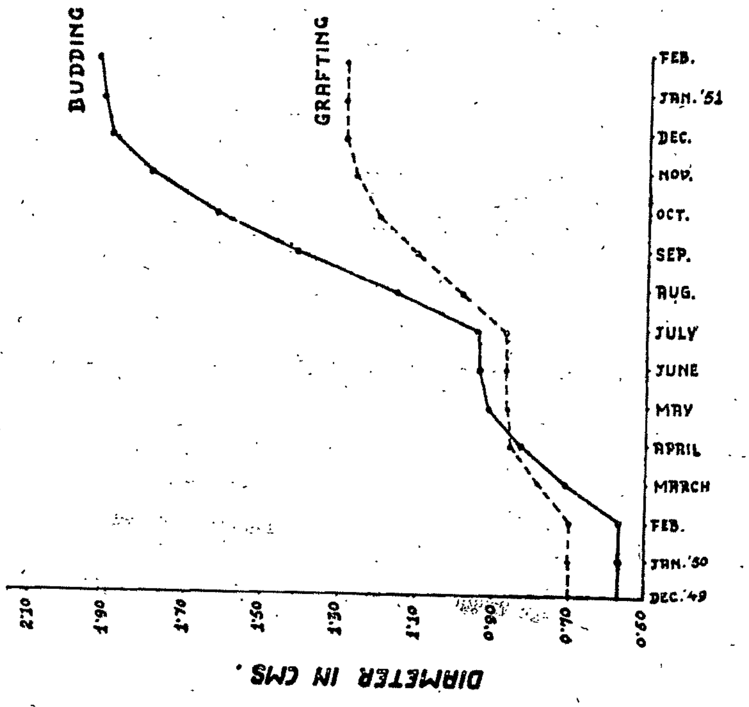
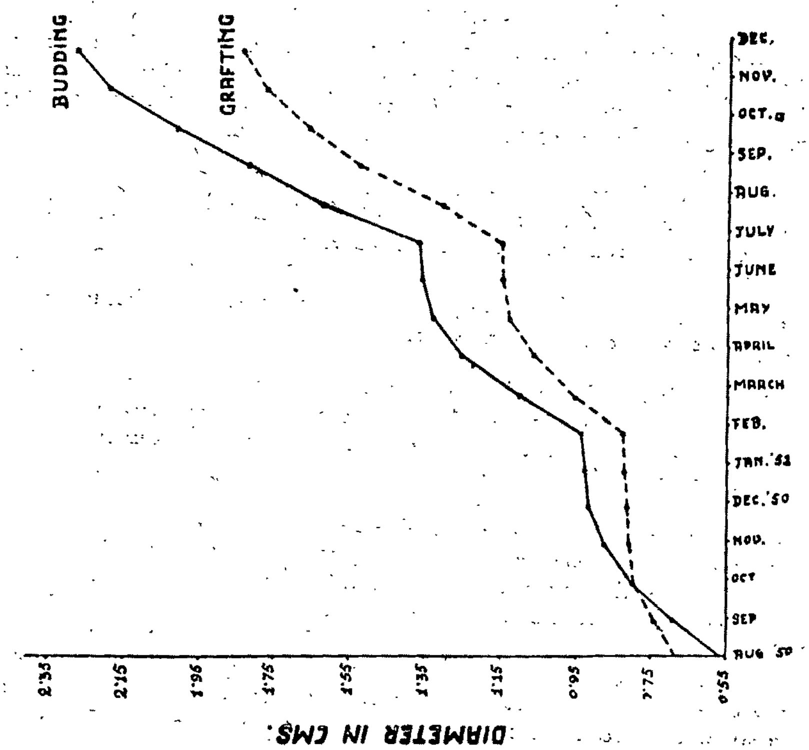


Fig. 4

SHOWING THE MEAN RATE OF MONTHLY GROWTH IN DIAMETER OF PLANTS PROPAGATED IN FEBRUARY.



Summary And Conclusions

Loquat plants were propagated by budding and grafting during the months of July and February to evaluate the desirability of the two methods for further multiplication of plants. Fifty plants were budded and grafted in each season. The percentage set, together with the growth of plants was recorded at regular intervals for 16 months.

The following conclusions have been derived :—

1. Plants budded in February had 20% higher set than those budded in July and the percentage of success was 76 and 56 respectively.

2. Grafting during July was slightly superior as compared to in February and the percentage of success was 88 and 84 respectively.

3. The ultimate mean height of plants varied from 69·5 to 110·3 cms. Stem elongation of plants grafted in July was significantly lower than that of February grafting or July and February budding. The maximum mean height of 110·3 cms was recorded of February budded plants.

4. The increase in diameter was closely related with the height of the plants and indicated a similar trend as observed in the stem elongation. The mean diameter of February budded plants was 1.308 cms as compared by 1.1271 cms of July budded and February grafted plants and 0.9412 cms for July grafted plants.

In view of the above findings it seems that budding is superior to grafting in both the seasons and that budding as well ss grafting in February generally result in better plant growth as compared to plants porpagated in July.

Literature Cited

1. Condit, I. J. 1935. The Loquat *California Agri. expt. Sta. Bull.* 250.
2. Firminger. 1930. Manual of Gardening in India Thacker Spink & Co. Calcutta.
3. Fraser, S. 1924. American fruits Orange, Judd. Publishing Co. New York.
4. Singh, C. P. 1937. The Loquat. *U. P. Dept. Agric. Fruit Series,* Bul. 19.
5. Wright, H. 1936. The Fruit grower's guide Virtue & Co.

Table I

Percentage ot success by the two methods of propagation of loquat in the two seasons.

	July		February	
	Budding	Grafting	Budding	Grafting
Percentage of succesr	56	88	76	84

TABLE II

Difference in the percentage of success by the two methods of propagation of loqua in the two seasons.

	Difference in percentage	Ratio of difference to S. E.
February grafting vs February budding	8—5.601	0.8922
July grafting vs July budding	32—6.384	4.5422
July budding vs February budding	21—66.240	8 1703
July grafting vs February grafting	4—5.119	0.5861
July grafting vs February budding	12—5.433	1.4725
February grafting vs July budding	28—6.481	4.0117

TABLE III

Mean height in cms per plant for the two methods of propagation of loquat in the two seasons.

	July		February	
	Budding	Grafting	Budding	Grafting
Mean height per plant	83.9	69.5	110.3	83.0

TABLE IV

Difference in mean height

	July budding	July grafting	February budding	February grafting
July budding	... ...	—14.4	26.4	—0.9
July grafting	14.4	... ...	40.8	13.5
February budding	—26.4	—40.8	... ...	—27.3
February grafting	0.9	—13.5	27.3	... ...

TABLE V

Average rate of growth of height in cms per plant for the two methods of propagation of loquat in the two seasons.

	July		February	
	Budding	Grafting	Budding	Grafting
Average rate of growth of height per plant	8.6	4.0	10.1	6.9

TABLE VI

Difference in average rate of growth n height.

	July budding	July grafting	February budding	February grafting
July budding	...	—4.6	1.5	—1.7
July grafting	4.6	...	6.1	2.9
February budding	—1.5	—6.1	...	—3.2
February grafting	1·7	—2.9	3.2	....

TABLE VII

Mean diameter per plant in cm s for the two methods of propagation of loquat in the two seasons.

	July		February	
	Budding	Grafting	Budding	Grafting
Mean diameter per plant	1.1271	0.9412	1.3082	1.1323

TABLE VIII

Difference in mean diameter

	July budding	July grafting	February budding	February grafting
July budding	...	—0.1859	0.1811	0.0052
July grafting	0.1859	...	0.3670	0.1911
February budding	—0.1811	—0.3670	...	—0.1759
February grafting	—0.0052	—0.1911	0.1759	...

TABLE IX

Average rate of growth in diameter Cms per plant for the two methods of propagation of loquat in the two seasons.

	July		February	
	Budding	Grafting	Budding	Grafting
Average rate of growth of diameter per plant	0.1056	0.0458	0.1077	0.0734

TABLE X

Difference in average rate of growth in diameter.

	July budding	July grafting	February budding	February grafting
July budding	...	—0.0598	0.0021	—0.0322
July grafting	0.0598	...	0.0619	0.0276
February budding	—0.0021	—0.0619	...	--0.0343
February grafting	0.0322	—0.0276	0.0343	...

FIBROIDS IN PREGNANCY

By Miss A.D. Engineer, M.D., M.R.C.O.G., F.R.C.S.,(E)
Professor of Obstetrics & Gynaecology, Medical College, Agra.

It is a well known fact that conception does not readily occur in a uterus which is the seat of fibroid tumours. However the association of fibroids and pregnancy is by no means unknown. It was with the idea of assessing the frequency of this association that the present survey was undertaken in the Department of Obstetrics & Gynaecology of the Sarojini Naidu Hospital, Agra.

Incidence.—This has been variously reported. Spencer (10) in 1920 said that they occurred about once in 150 pregnancies, and this appears to be a fair average. Huber and Hesseltine (5), in 1939, assembled the statistics on this subject from eleven large clinics in the U. S. A., England, France and Germany, representing a total of over 200,000 pregnant women. These combined statistics showed that fibroid tumours were discovered in about 0.5 per cent of pregnant women, the reported incidence varying between 0.3 per cent and 1.4 per cent. Pierson, (8) in his series of 30,836 pregnancies noted an incidence of 0.8 per cent, but regarded only 76 per cent of them as being of "clinical significance".

In the Sarojini Naidu Hospital, in the last 6 years, the following incidence has been recorded :

Number of pregnancies	8,345
Number of cases with fibroids	11
Primigravidae	3
Multigravidae	8
Incidence	0.13 per cent

These figures show a preponderance of multigravidae over primigravidae, a finding which is at variance with Watson's (11) widely accepted contention that parous women are less liable to develop these tumours, but the early age of marriage in this country as compared to the other countries may be a factor.

In most records elderly primigravidae head the list. This is because women with fibroids have a low fertility and many years elapse before conception occurs. The three primigravidae in this series were aged 23,32 and 35. The youngest patient was 27, and the oldest 36.

Effect of Fibroids on Pregnancy,.—In this series of 11 cases, 5 had normal pregnancies (45.5 per cent). All three primigravidae belonged to this group, while the remaining two were multigravidae.

Most authors have stressed the fact that only in a small percentage of cases are the tumours of "clinical significance". Mussey and Hardwicke(7)regarded only one-third of their cases as important, while Polak(9)in 1928 stated that in his personal series of 7,000 cases "there were but 6 tumours which required removal during pregnancy, and 4 which demanded section during labour to accomplish delivery". This view is shared by Munro Kerr (6) and Whitridge Williams.(12) The tumours "of clinical signifi-ficance", on the other hand, produce very definite complications during pregnancy. Their commonest effect is to predispose to abortion and premature labour (6, 12). Another result is the occurrence of malpresentations, which if uncorrected, may produce dystocia at the time of labour. Pressure symptoms may arise, as an increase in the size of the tumours occurs during pregnancy. Symptoms such as retention of urine may occur as the result of the impaction of a small tumour in the pelvis. A placenta praevia may result from interference with the normal implantation of the placenta, and an ectopic gestation may occur if the tumour is in such a position as to produce kinking of the fallopian tube. Each of these complications will now be considered in relation to the cases seen.

Premature interruption of Pregnancy. This occurred in 4 cases (36.3 per cent). In Watson's series (11), it occurred in 45 per cent, while Pierson (8), gives a figure of 24.1 per cent. Premature labour took place in one case at the thirty-second week. Abortion occurred in 3 cases (27 per cent), in one at the sixteenth week, and in the other two at the twentieth week. All patients were multigravidae and two of the cases terminated fatally. The first patient (Case 7 in Table had a sloughing submucous tumour and was admitted in a moribund condition 10 days after an abortion at home.

She had a temperature of 102 F.and was almost exsanguinate. A large haemorrhage occurred a few hours after admission and she expired while arrangements for transfusion were being made.

The second patient (Case 8 in Table) had multiple tumours including a large anterior cervical one. The os was reached with difficulty and was dilated one finger. A total hysterectomy was advised as it was felt that the cerviacal tumour would hinder dilatation of the cervix. The patient however refused operation, and left the hospital against medical advice, and I understand, subsequently miscarried at home and expired a few hours later of severe post partum haemorrhage.

The third patient (Case 10 in Table III), miscarried in the hospital, and had an uneventful convalescence.

It should be noted that in all 3 cases, abortion took place after the twelfth week, a point which Pierson (8) has stressed.

Threatened abortion (where the pregnancy continued) occurred in one case (Case 5). This patient was admitted at the twelfth week with slight bleeding and severe pain in the abdomen due to the occurrence of "red degeneration" in one of the tumours. Myomectomy had to be performed as the pain persisted unabated under the usual conservative treatment. The pregnancy continued uninterrupted, contrary to all expectations, and the patient had an easy spontaneous delivery at term. This patient had two previous abortions also, so the tumours were undoubtedly responsible for their occurrence.

Malpresentations. This was found in one case only (9.1 per cent) in which a persistent transverse presentation necessitated a classical caesarean section at term.

Pressure symptoms were not noted in any of the cases. Placenta praevia and ectopic pregnancy were not encountered.

The Effect of Pregnancy on Fibromyomata.—As pregnancy advances the tumours become larger and softer, owing to increased vascularity, oedema and hypertrophy and hyperplasia of the muscle fibres. The softening may be so marked as to cause difficulty in diagnosis, as occurred in Case 3, in which a broad ligament tumour had undergone so much softening as to be mistaken for an ovarian cyst. In most cases, upward displacement of the tumours occurs the pregnancy proceeds, (12) but sometimes moderate-sized tumours may get impacted in the pelvis and produce such urgent symptoms as to necessitate immediate operation. This fortunately did not occur in any of our cases.

The most frequent complication, according to Watson (11), is the occurrence of "red degeneration." This may occur at any time during pregnancy or the puerperium. In this series it occurred in 2 cases (18.2 per cent). One case was treated conservatively, while in the other, myomectomy had to be performed. In both cases pregnancy proceeded uneventfully to term. The increased frequency of this complication during pregnancy has been attributed by Browne (1) to thrombosis in the arteries supplying the tumour due to the increase in the fibrinogen content of the blood during pregnancy, but it has also been stated (2) that the greatly increased growth of the tumour under the hormonal influence of pregnancy, makes it outstrip its blood supply. Consequent on this interference wih its blood supply, the empty capillaries of the tumour become engorged with venous blood, rupture and stain it with extravasated blood. The centre of the tumour finally becomes occupied with necrotic material, which is very liable to get infected. This liability to infection is probably the reason for not advocating myomectomy for such tumours. The consensus of opinion is that the treatment of the condition should be conservative as far as possible and operative interference should only be undertaken under exceptional circumstances.

Other rare complications that have been produced as a result of pregnancy are torsion of the gravid uterus, torsion of the pedicle of a subperitonral tumour and intraperitoneal bleeding from a ruptured vein on the surface of the tumour (6) but these were not encountered in any case in this series.

Myomectomy had to be performed during pregnancy on one occasion only, the indication being the persistence of severe pain in a tumour which had undergone "red degeneration" in spite of the usual conservative treatment. The pregnancy continued undisturbed after the operation and the patient had an easy spontaneous delivery at term (Case 5).

The risk attached to the operation during pregnancy is about 0.5 per cent more than when it is performed in the non-pregnant, (5) but the risk of abortion following it is very great. Its performance is fortunately rarely necessary. Watson (11) performed it 3 times in 157 cases : 1 patient aborted, hysterotomy was necessary in the second to control haemorrhage, while the third went to term. Of Gemell's 475 cases 65 miscarried and 14 died, (3) while of Mussey and Hardwicke's 32 cases 12 aborted and one died.

TABLE OF COMPLICATIONS DURING PREGNANCY
Total number of cases 11.

	No. of cases	Percent.
Normal pregnancy	5	45.5
Threatened abortion	1	9.1
Abortion	3	27.3
Premature labour	1	9.1
Red degeneration (1 case with thr. ab.)	2	18.2
Myomectomy	1	9.1
Malpresentations	1	9.1

Effect of Fibromyomata on the Course of Labour.—In this series of 11 cases, 5 had normal deliveries (45.5 per cent), although one of them was premature.

The influence of the tumours on the course of labour will depend upon the situation and size of the tumours. Most tumours are drawn up as pregnancy advances, and so the percentage of cases where the tumour is responsible for obstruction, is small (18). If however, the tumours arise from either the lower segment or the cervix, this is almost certain to occur. Two such cases were encountered : One was a primigravida with a large fibroid in the lower segment, admitted during labour on whom a classical caesarean section had to be performed (Case 2 in Table III) This patient also had an osteomalacic pelvis, and so a caesarean section would have been necessary in any case, even without the fibroid. The second patient was a multigravida with multiple tumours, one of which was a large cervical one (Case 8 in Table III). She was admitted with symptoms of threatened miscarriage. A total hysterectomy was advised as it was felt that the cervical tumour would interfere with the dilatation of the cervix, but the patient refused this and left the hospital against medical advice. It was subsequently reported that she had a retained placenta and expired at home of severe post partum haemorrhage.

Malpresentations. There was one case in which the tumours were responsible for a persistent transverse presentation which necessitated the performance of a caesarean section at term (Case 9 in Table III). This was the only case of malpresentation in the series.

Uterine Inertia. This was present only in one case in a primigravida of 32 who had to have a forceps delivery (Case 4 in Table III). Pierson (8) encountered it in 34.6 percent of cases, and (2) Buckell in 9.1 per cent.

Forceps Delivery. This was necessary in one case (9.1 per cent) due to delay in the second stage. In Pierson's series (8) it was necessary in 20 per cent of cases while in Buckell's (2) it was necessary in 12.5 per cent.

Caesarean Section. This was necessary in 2 cases (18.2 per cent), a figure slightly lower than that reported by other authors (Watson 22.3 per cent, Buckell 22.3 per cent). In the first case it was necessary for an obstructing fibroid (case 2 in Table III), while in the second it was performed for a persistent transverse presentation in a case of secondary sterility of 9 years duration (Case 9 in Table III). Two small fibroids were shelled out of the anterior wall at the time of operation in the second case, but myomectomy was not combined with the caesarean section in the first case as it was felt that the shock of the double operation would be too much for the patient.

Post partum haemorrhage. This is a serious complication and was encountered in two cases (18.2 per cent). Both were post abortal cases and both ended fatally. The incidence of post-partum haemorrhage has been reported as 33.6 per cent by Pierson and 25 per cent by Polak. Watson found that it only occurred in 1.9 per cent of cases, while Harris thought that it was likely to occur only if the placenta were implanted over the tumour.

TABLE OF COMPLICATIONS DURING LABOUR.
Total Number of Cases 11.

	No. of Cases	Per Cent.
Uterine inertia	1	9.1
Forceps delivery	1	9.1
Caesarean section (combined with myomectomy in 1 case)	2	18.2
Post partum haemorrhage	2	18.2

Effect of Fibroids on the Puerperium.—In this series complications were encountered in the puerperium in 4 cases (36.4 per cent). Morbidity was noted in 3 cases—in one case after an abortion at home, in another after a forceps delivery and in the third following a classical caesarean section combined with myomectomy.

In the fourth case myomectomy had to be performed on the fifth day in the puerperium for severe pain in a large and very much softened broad ligament tumour wrongly diagnosed as a twisted ovarian cyst. (Case 3 in Table.)

TABLE III SUMMARIZING COMPLICATIONS DURING PREGNANCY, LABOUR & PUERPERIUM.

Case	Rarity	Type of Tumour	Complications Pregnancy	During Labour	Puerperium	Maternal Death	Abortion
1.	III	Small tumour at fundus.	Red degeneration at 24th week. (Treat. conservative).	Nil (Spont. del. at term).	Normal		
2.	I	Interstitial tumour from ant. aspect of lower segment.	Nil	Obstructed Labour Classical C. S.	Normal	...	...
3.	IV	Large Broadlig Tumour.	Nil	Nil (Spont del. at term).	Morbid myomectomy on 5th day for severe pain in tumour	...	...
4.	I	Multiple small tumours at fundus.	Nil	Prolonged 2nd stage. Forceps del.	Morbid	...	
5.	III	Interstitial fundus & subserous on body of uterus	Threatened abortion 12th week. Red degeneration. Myomectomy	Nil (Spont. del. at term)	Normal	...	...
6.	II	Multiple tumours of body	Premature termination (32 week)	Nil	Normal	...	...
7.	IV	Sloughing submucous tumour	Abortion of 16 Wks at home 10 days ago.	...	morbid severe pph.	1 (pph)	1
8.	V.	Multiple tumours body, large cervical one.	Abortion of 20 wks. at home after leaving against medical advice	...	...	1	1 (Severe pph retained placenta).
9.	II	Two small tumour ant. wall.	Malpresentation (Persistent Transverse)	Classical Caesarean with Myomectomy	Morbid	...	...
10.	III	Multiple tumours of body	Abortion at 20th wk.	...	...	...	1
11.	I	subserous tumour at fundus	Nil	Nil (Spont. del. at term)	Normal	...	...

Maternal Deaths.—Two patients expired, one in the hospital, and one in her own home. The cause of death in both was severe post-abortal haemorrhage. Details of both cases have been given above.

Infant Report.—All children were born alive except in the 3 cases who aborted. Only one child was premature (32 weeks) and this was the only neonatal death. The percentage of children lost (abortions and neonatal deaths) is therefore 36.4 per cent.

Most reported series have stressed the high foetal mortality rate. Pierson(8) recorded one of 35.6 per cent and Mussey and Hardwicke (7) one of 28.9 per cent. In Buckell's (2) series it was 30.4 per cent while Watson recorded one of only 12.7 per cent.

Summary and Conclusions.—Eleven cases of fibroids in pregnancy have been described and the complications encountered discussed. The incidence of the association was 0.13 per cent. Twenty seven per cent of the patients were primigravidae. Complications occurred during pregnancy in 55.5 per cent of the cases and in 45.5 per cent of cases during labour. The abortion rate was 27.3 per cent.

Myomectomy was performed on 3 occasions, once during pregnancy for a tumour that had undergone red degeneration and which did not respond to the usual conservative treatment, once during the course of a caesarean section and once during the puerperium on a tumour which had undergone cystic degeneration under the mistaken diagnosis of twisted ovarian cyst. The operation is safest during pregnancy, less so at the time of caesarean section and least so during the puerperium.

Forceps application was necessary in only one case (9.1 per cent) on account of uterine inertia.

Caesarean section was performed in 18.2 per cent of cases. It is the safest mode of delivery in cases with an obstructing fibroid or in the presence of malpresentations. There were 2 maternal deaths (18.2 per cent), both from post abortal haemorrhage.

Of the 11 cases, 7 (63.6 per cent), had living children. There was one premature birth and one neonatal death. Submucous tumours and those arising from the cervix proved to be the worst offenders as regards their capacity to produce complications during pregnancy, labour and the puerperium. and were responsible for both the deaths in this series.

Acknowledgements.—My thanks are due to Dr. H. N. Bhatt, Principal, Medical College, Agra for permission to utilize the Hospital records, and to Dr. R. C. Saxena, M. S., Lecturer in my Department for furnishing details about Case 9 which was under his case.

REFERENCES

1. BROWNE, F. J. 1944. "Ante-Natal & Post-natal Care, 5th Edition, p. 528.
2. BUCKELL, E. W. C. 1947. *J. Obstet. & Gynaecol. British Emp.*, 70.
3. GEMMELL, A. A. 1936. *J. Obstet. & Gynaecol. British Emp.*, **48** : 736.
4. HARRIS, R. H. 1929. *Surg. Gynec. & Obstet.*, **49** : 322.
5. HUBER, Carl, and HESSELTINE, H. CLOSE. 1936. *Surg. Gynec. & Obstet.*, **68** :699-702.
6. KERR, J. MUNRO. 1937. Operative Obstetrics 4th edition, 319.
7. MUSSEY, R. D. and HARDWICKE R. S. 1935. *Amer. J. Obstet. & Gynec.* 29, 92.
8. PIERSON, R. N. 1927. *Amer. J. Obstet. & Gynec.*, **14** : 333.
9. POLAK, J. O. 1928. *Surg. Gynecol. & Obstet.*, **46** : 21.
10. SPENCER, H. "Tumours Complicating Pregnancy, Labour & Puerperium. London, 1920.
11. WATSON, B. P. 1932. *Amer. J. Obstet. & Gynec.*, **23** : 351.

A CRITICAL STUDY OF THE VARIOUS METHODS OF EVALUATING STRUCTURAL PARACHORS

By S. N. Kaveeshwar and W. V. Bhagwat, *Chemistry Department, Holkar College, Indore.*

From the consideration of parachors of isomerides, such as esters $C_6H_{12}O_2$ or *o*-, *m*-, *p*- derivatives of di-substituted benzene and of the geometrical isomerides, Sugden (19) came to the conclusion that parachor is purely an additive property. From the study of the parachor of homologous series of paraffins, benzene hydrocarbons, esters, ketones, nitriles and amines he obtained the value of 39 for CH_2 group. He then calculated the parachor of H and C atoms from the parachors of hydrocarbons. Similarly he arrived at other values for other atomic and structural parachors (Sugden (21). His values are given below.

C	4.8	O_2 in esters	60
N	12.5	Semipolar Bond	-1.6
O	20.0	Triple Bond	46.6
F	25.7	Double Bond	23.2
Br	68.0	3-membered Ring	16.7
H	17.1	4 ,, ,,	11.6
P	37.7	5 ,, ,,	8.5
S	48.2	6 ,, ,,	6.1
Cl	54.3	8 ,, ,,	2.4
I	91.0	Napthalene Ring	12.2

Mumford and Phillips (13) have criticised Sugden's constants on the ground that they were mainly evaluated from the earlier members of various series of organic compounds irrespective of whether they had straight or branch chains. The work of Hunter and Maass (12), Edgar and Calingaert (4), Richards, Speyers and Carver (15) showed that normal compounds have highest parachors, while those of branch chain isomerides decrease in proportion to the number of side chains present. This observation is further supported by Schiff (16,17), Harkins, Clark and Roberts (10), and by Harkins (11). Mumford and Phillips (13), therefore, suggested that a more accurate estimate of CH_2 increment would be obtained by taking into consideration series consisting of compounds of one type only, i. e. all iso or normal. They obtained a new system of atomic and structural parachor. The scheme includes allowances known as strain constants, for branching chains, for negative groups and for alkyl substituents in the benzene ring. Their values are given below.

CH_2	40.0	O	20.0
C	9.2	S	50.0
H	15.4	Se	63.0
F	25.5	B	21.5
Cl	55.0	Si	31.0
Br	69.0	Be	42.0
I	90.0	Al	55.0
N	17.5	Cr	58.0
P	40.5	Tl	62.0
As	54.0	Sn	64.5
Sb	68.0	Hg	69.0
Bi	80.0		

Triple Bond	+38.0	3-Membered Ring	+12.5
Double Bond	+19.0	4- ,, ,,	+6.0
Single Bond (Duplet)	+0	5- ,, ,,	+3.0
Semipolar Double Bond	0	6- ,, ,,	+0.8
Singlet linkage	-9.5	7- ,, ,,	—4.0

Vogel (22, 23, 24, 25, 26, 27, 28) in a series of papers has studied the parachor of a number of compounds. This work was undertaken to obtain accurate values by taking highly purified organic compounds with a view to test known relationships between physical properties and chemical constitution and to deduce new ones. Like Mumford and Phillips (13) he assumed that the value 39 for CH group assumed by Sugden is too low and obtained new constants for atomic and structural parachors. His values are recorded below.

CH_2	40.0
C (in CH_2)	8.6
H (in CH_2)	15.7
O (in ethers)	19.8
O (in acetals)	18.0
CO (in ketones)	44.4
C O (in methyl ketones)	46.7
C O O (in esters)	63.4
OH (in alcohols)	30.2
CO·OH	73.7
Cl	55.2
Br	68.8
I	90.3
F	26.1

NH_2 (in primary aliphatic amines)	44.0
NH (in secondary aliphatic amines)	28.4
NH (in secondary aromatic amines)	27.1
N (in tertiary aliphatic amines)	7.2
NO (nitroso)	53.4
O.NO (nitrite)	75.3
NO_2 (nitro)	73.8
N.NO (nitrosoamine)	68.0
S (in sulphides)	48.6
S_2 (in disulphides)	97.2
SH (in thiols)	66.4
CS (in xanthates)	74.2
SCN (in thiocyanates)	112.0
NCS (in isothiocyanates)	113.9
$C=C$	19.9
$C\equiv C$ (terminal)	40.6
CN (in nitriles)	64.6
3—C ring	12.3
4—C ring	10.0
5—C ring	4.6
6—C ring	1.4
CO_3 (carbonates)	82.4
SO_3 (sulphites)	105.3
NO_3 (nitrates)	92.9
SO_4 (sulphates)	123.4
PO_4 (orthophosphates)	107.8
CH_3	55.4
C_2H_5	95.4
n-C_3H_7	135.5
i-C_3H	133.8
n-C_4H_9	175.8
i-C_4H_9	173.8
s-C_4H_9	171.2
n-C_5H_1	215.0
i-C_5H_{11} (from synthetic alcohols)	212.6
i-C_5H_{11} (from fermentation alcohols)	213.1
n-C_6H_{13}	255.0
n-C_7H_{15}	295.7
n-C_8H_{17}	335.7
C_3H_5 (allyl)	124.3
C^6H_5	188.3

Gibling (5, 6, 7, 8, 9,) has discarded Sugden's values for atomic and structural parachors and has suggested his own values for atomic and structural parachors. According to him it is more accurate to substitute group parachors for atomic parachors and structural constants. He has introduced a term called "Expansion Correction" which has to be added to "Standard Values" to get the correct calculated values. These are to be then compared with the observed values. He claims better agreement between calculated and observed results. His values are summarized below :—

$CH_3.C—$	55.2	C.OC.	21 5
$C.CH_2-C—$	39.8	C.CHO	67.3
${}^{C}_{C}{>}HC.C—$	20.2	C.CO.C	50.9
${}^{C}_{C}{>}C{<}{}^{C}_{C}$	2.4	C.CO.O.C.—	66.4
C.CH=C—	34.3	$O=C(OC)_2$	85.5
${}^{C}_{C}{>}C=C$	16.7	$CH_2=C$	49.7

In parts III and IV of his paper on molecular volume and structure Gibling, (6) has given new values to these groups under uncorrected conditions for "interference" between the linked atoms. For every interference between C-C atoms a value of 2.2 is added. Thus for C.CHC the value becomes 42 and 28.8 for ${}^{C}_{C}{>}CH-C$

On the basis of uncorrected values he has proceeded to determine the values for various rings. Thus he suggested following ring corrections :—

Cyclopentane ring	—5.4
Cyclohexane	—10.7
Benzene ring	—13.4

Mumford and Phillips (14) have again reopened the topic of atomic and structural parachors. We have, therefore, thought it necessary to study very critically the various views since, a large amount of parachor data is now available compared to what existed when Sugden initiated the subject of parachor.

The great significance of Sugden's work lies in the fact (1) that his basis is most general. He assumes that the property of parachor is strictly additive and the position of atoms and structures in a molecule does not matter. He thus attributes same parachor to isomerides. This point is objected to, by all other workers mentioned above. However, there seems to be a fundamental difference between the approach of Sugden and others. (2) Sugden desired to see, how far the property of parachor can be used for elucidating doubtful structures of molecules. On the other hand, other workers have tried to find, how far the atomic and structural values when substituted can reproduce the experimental values. Gibling (5,6, 7, 8, 9,) has gone to such an extreme, that he has attributed values of parachors to every possible grouping and position in a molecule. In doing so he has lost the sight of the fact that his method has become purely empirical and has lost its general value.

The case of ortho, meta and para compounds may be taken as an example. Gibling gives -2.7, -1.7 and -2.2 as parachor values for ortho, meta and para positions. We have summarised the parachor values of ortho, meta and para compounds observed by various workers in the following table, together with their differences.

	Observed Parachor				*Parachor Difference*	
Compound	ortho	meta	para	o-m	m-p	p-o
Chlorotlouene	280.8	—	283.6	—	—	2.8
Nitro-toluene	301.1	300.6	301.6	+0.5	—1.0	+0.5
Nitro-anisole	320.5	—	322.0	—	—	+1.5

	Observed Parachor				*Parachor Difference*	
Compound	ortho	meta	para	o-m	m-p	p-o
Chloro-nitro-benzene	299.9	298.9	300.0	+1.0	—1.1	+0.1
Bromo-nitro-benzene	312.9	313.5	313.5	—0.6	±0.0	+0.6
Xylene	283.3	284.6	283.8	—1.3	+0.8	+0.5
Methyl azo-benzene	463.8	467.3	—	—3.5	—	—
Nitro-phenol	273.2	283.3	280.8	—10.1	+2.5	+7.6
Hydrcxy benzaldehyde	268.0	274.5	278.2	—6.5	—3.7	+10.2
Methoxy azo benzene	486.9	486.9	485.0	±0.0	+1.9	—1.9
Toluyl azoimide	303.8	—	307.0	—	—	+3.2
Cresol	257.5	277.1	—	+0.4	—	—
Toludine	269.3	—	272.4	—	—	+3.1
Toluonitrile	292.5	295.6	295.2	—3.1	+0.4	+2.7
Methoxy benzaldeyde	312.4	—	313.9	—	—	+1.5
Toluyisocyanide	292.9	—	295.5	—	—	+2.6
Anisylisocyanide	314.1	—	314.5	—	—	+0.4
Gibling's values	—2.7	—1.7	—1.7	—2.2	—1.0	+0.5
Xylene [Refer (3)]	232.41	284.21	284.45	—1.80	—0.24	+2.04
Methyl Ethyl benzene	319.88	322.83	323.30	—2.95	—0.47	+3.42
Diethyl benzene	357.64	361.01	361.39	—3.37	—0.38	+3.75
Trimethyl benzene	317.58	320.33	321.88	—2.75	—1.55	+4.30

It is to be noted that although Quayle's values for meta and para xylenes agree with other workers, his value for ortho is lower. Bhagwat (1, 2) and R. Donaldson and O. R. Quayle (3) have also suggested that value be attributed to 0, m and p positions.

According to Sugden 0·2%-0·5% error in the measurement of parachor is possible. As all the above values are near about 300, an error of 0·6-1·5 units is not unexpected. The differences in parachor in majority of above cases are of this order. Further they are not always of the same sign *i. e.* positive or negative, nor they are constant. The actual values attributed by Gibling are of the order of the error possible. Considering all these things we state that o-, m- and p-positions may cause a change in parachor but that varies from compound to compound and is not large enough to be structurally useful in differentiating o-, m-, and p-compounds. No values therefore can be attributed to them. The deviation in case of o-nitrophenol and o-hydroxy-benzaldehyde is very large and is well explained by Sidgwick (18) on the basis of hydrogn bonding. It will be seen, therefore, that Gibling's method is not very useful for generalisation, but attempts fundamentally in equating the calculated and observed parachors, which by themselves are liable to contain percentage error.

The second important point of difference between Sugden and others is the value of CH_2 group. According to Vogel (22, 23, 24, 25, 26, 27, 28) and Mumford and Phillips (13, 14) the value 39 as suggested by Sugden is too low. Gibling goes one step further to say that it increases as we ascend a homologous series. He therefore suggests an arbitrary correction called "expansion correction" to be applied to all molecules. Obviously the value of correction varies, depending on standard value of parachor of a molecule. This, in our opinion, is an arbitrary way of reproducing results as nearly correct as possible to the experimental results. Further it is to be proved in several homologous series that there is a regular increase in the value of CH_2 group as we ascend the series. We shall take this point later. Our objection to the method of evaluating the value of parachor of CH_2 group by Mumford and Phillips and Vogel is that they are committing the same error for which they are criticising Sugden, in assuming that the parachors of all other atoms as Cl, Br, etc. do not depend on their position in the molecule.

If the value of CH_2 can vary, the value of other atoms can also vary. In that case there is no propriety in taking common differences for CH_2. Secondly the values of parachor as given by various workers have to agree and their accuracy should be beyond doubt, if correct structural values are to be determined. For same author and for same substance, the values differing by one or two, or even more units are common. Further Vogel (*loc. cit.*) observed a variation in parachor according as a substance is prepared by one method or another. Hence the deviation or identities of differences may be called accidental. The following table will show how the parachor values differ with the worker.

Compound	*M & P**	*B. A. R*		*V*	
Ethyl bromide	165.2	165.7	167.6	165.4	165.1
n-propyl bromide	—	205.3		203.9,	203.6
n-propyl chloride	191.6	190.2		191.7	
i-propyl bromide	205.9	205.1		205.1, 206.7, 203.9	
i-butyl bromide	241.5	243.8		244.1, 246.8	
n-amyl chloride	269.9	270.4		270.2	
i-amyl bromide	—	282.2		280.6, 282.6	

It is to be noted that authors give these values as a mean of a number of values.

We have, therefore, now followed a new procedure to fix up correct values for the parachor of various compounds. (1) Firstly we have tried to find whether the parachor differences of atoms say Cl-F or Br-Cl come out to be constant. If they do so within experimental errors, the mean is taken as a correct difference. The parachor of compounds is then adjusted, so as to give a difference which will agree more or less with the correct mean differences fixed as above for various atoms. After fixing these corrected values of parachor for compounds, we will proceed to get the value for CH_2 group and for other atoms and structures. The values so found for atomic and structural parachor will then be the standard values. When there are a number of values available, mean is taken only of those values which are very near to one another. In other cases the value is left for being fixed up, after the mean difference has been determined. If the difference of parachors of atoms shows more or less a constant value and a slight variation, it means that atomic parachor is affected by the position of atom, but the parachor value is of such an order that it cannot be usefully evaluated as a structural value. The atomic parachor in such cases is taken as constant and independent of the position of the atom in the molecules. Following results will illustrate the method.

---

* In this and subsequent pages the abbreviations used stand for M & P is Mumford and Phillips., B.A.R. is British Association Report (1932). V is Vogel.

PARACHOR DIFFERENCES FOR CL AND F

Compound	*M & P*	*B. A. R.*	*V*	Mean.	Cl=F
p-chloro-toluene			282.7		
p-fluoro-toluene			254.0		28.7
n-ocyl chloride	390.1		390.2	390.1	28.8
n-octyl fluoride			361.3		
n-hexyl chloride	310.2		310.5	310.4	28.4
n-hexyl fluoride			282.0		
n-amyl chloride	269.9	270.4	270.2	270.2	28.6
n-amyl fluoride			241.6		
Chloro-benzene		244.2	243.2	243.7	28.6
Fluoro-benzene			214.4	215.1	
Benzene-sulphonyl chloride			329.5 (fixed)	328.0	28.5
Benzene-sulphonyl fluoride			298.0	299.5 (fixed)	

The mean of the first four values is 28·6. It is possible to take mean of parachor values of chlorobenzene, but there is only one value available for fluorobenzene. Hence it is fixed as 215·1. In the next case only one value for each is available, hence each is fixed on the ground that a variation of 0·5% is possible as an experimental error.

GROUP VALUE FOR CH^2

Compound	Para.	Diff.	CH^2	Value
n-octyl chloride	390.1			
		79.7	2 x	39.8
n-hexyl chloride	310.4			
		40.2	1 x	40.2
n-amyl chloride	270.2			
n-octyl fluoride	361.3			
		79.3	2 x	39.6
n-hexyl fluoride	282.0			
	40.4	1 x	40.4	
n-amyl fluoride	241.6			

Mean——39.9

The results do not support Gibling's view that the value for CH_2 increases steadily as we ascend a homologous series.

PARACHOR DIFFERENCE FOR BR-CL

Compound	*M & P*	*B. A. R.*	*V*	Mean	Br—Cl
Bromo benzene		258.0	257.1	257.5	
Chloro benzene		244.2	243.2	243.7	
Allyl bromide			192.7		13.1
Allyl chloride			179.6		
α-bromo napthalene			361.5		13.0
α-chloro napthalene			348.5		
n-nonyl bromide			444.0		13.0
n-nonyl chloride			431.0		
n-hexadecyl bromide			725.3		13.5
n-hexadecyl chloride			711.8		
n-octyl bromide	403.0	402.4	403.8	403.1	13.0
n-octyl chloride	390.1		390.2	390.1	
n-heptyl bromide	363.0	363.0	363.5	363.2	13.4
n-heptyl chloride	349.0		350.7	349.8	
o-bromo nitro benzene		312.9			13.0
o-chloro nitro benzene		299.9			
p-bromo nitro benzene		313.5			13.5
p-chloro nitro benzene		300.0			
Ethylene di bromide		215.5	215.2	215.4	2 x 13.5
Ethylene di chloride		189.1	188.6	188.8	
1: 3 di bromopropane			256.4		2 x 13.4
1: 3 diechloro-propane			229.7		
Propylene di bromide			253.3		2 x 13.5
Propylene di chloride			226.6		
Trimethylene dibromide			256.5		2 x 13.5
Trimethylene dichloride			229.4		
Methylene dibromide			175.1		2 x 13.9
Methylene dichloride			147.5		
Ethyledine dibromide			215.4		2 x 13.9
Ethyledine dichloride			187.6		
Ethyl bromide	165.2	165.7	165.4	165.3	13.7
Ethyl chloride		151.6	165.1		
n-propyl bromide		205.3	203.9	204.2	

			203.6		13.0
n-propyl chloride	191.6	190.2	191.7	191.2	
i-propyl bromide	205.9	205.1	205.1	205.4	
					13.5
i-propyl chloride			191.9	191.9	
n-butyl bromide	243.9	243.5	243.8	243.7	
			243.0		13.3
n-butyl chloride	230.4	230.5	230.3	230.4	
i-butyl bromide	241.5	243.8	244.1	241.7	
			246.8	(fixed)	13.5
i-butyl chloride	228.1	228.4	228.2	228.2	
n-amyl bromide	283.2	283.6	283.1	283.3	
					13.1
n-amyl chloride	269.9	270.4	270.2	270.2	
Sec. butyl bromide			243.5	243.8	
			244.2		13.4
Sec. butyl chloride			230.4		
i-amyl bromide		282.2	280.6	282.3	
			282.6	(fixed)	13.2
i-amyl chloride		269.8	268.8	269.1	
			269.2		
n-hexyl bromide	323.7	322.8	323.3	323.7	
			322.8	(fixed)	13.3
n-hexyl chloride	310.2		310.5	310.4	
Bromoform		212.9	227.8	223.2	
				(fixed)	3 x 13.3
Chloroform	183.1	183.4	183.2	183.2	
Thio carbonyl tetra bromide			316.4	318.0	
				(fixed)	13.7
Thio carbonyl tetra chloride			266.1	265.0	
				(fixed)	
Acetylene tetra bromide			310.5	311.5	
				(fixed)	4x 13.2
Acetylene tetra chloride			260.0	259.0	
α-α^1 dibromo phorone			463.2	Values cannot be fixed as the	
α-α^1 dichloro phorone			427.7	diff. is large.	
n-propyl bromo acetate			305.2	306.0	
				(fixed)	
n-propyl chloro acetate			292.3	292.3	
n-butyl bromo acetate			343.8	344.5	
				(fixed)	13.5
n-butyl chloro acetate			331.9	331.0	
				(fixed)	
βBromo pentane			280.9	281.5	
				(fixed)	13.5
β-chloro pentane			268.4	268.0	
				(fixed)	
γ-bromo pentane			281.7	281.7	
					13.5
γ-chloro pentane			269.4	268.2	
				(fixed)	
n-decyl bromide			484.6	485.6	
				(fixed)	13.6
n-decyl chloride			472.0	472.0	
n-undecyl bromide			523.7	524.7	

		(fixed)	13.5
n-undecyl chloride	511.9	510.2 (fixed)	
n-dodecyl bromide	566.3	565.0 (fixed)	13.6
n-dodecyl chloride	549.7	551.4 (fixed)	

The mean value of Br-Cl is taken as 13·5 and then other values are fixed. It will be observed that value of Br-Cl varies from 13 to 13·9 and hence is not absolutely constant. In other words the parachor values of atoms slightly change with its position in the molecule. A variation of ± 0.2 is possible in best results. Hence the variation of 0.4 from mean value is inevitable. Thus the variation due to the position of an atom is not significant enough to be judged correctly by parachor. We assume therefore that atomic parachors of F, Cl, and Br are constant.

PARACHOR DIFFERENCE FOR I-BR.

Compound	*M & P*	*B. A. R.*	*V*	*Mean*	*P *Br	I-Br
Ethyl iodide	186.7	187.0	186.6 187.3	186.9	165.3	21.6
n-propyl iodide	226.1	226.0	226.2 225.8	226.0	204.2	21.8
n-butyl iodide	264.9	264.7	264.6 267.2	264.9	243.7	21.2
i-butyl iodide		265.0	264.7	263.5 (fixed)	241.7	21.8
n-amyl iodide			305.1 304.6	304.9	283.3	21.6
Sec.-butyl iodide			266.6	265.6 (fixed)	243.8	21.8
i-amyl iodide			302.7 304.3	303.5	282.3	21.2
β-iodo pentane			301.8	302.8	281.5	21.3
γ-iodo pentane			302.9	302.8	218.7	21.2
n-hexyl iodide	345.7	344.1	348.8	345.0 (fixed)	323.7	21.3
n-heptyl iodide		384.5	386.6	384.5 (fixed)	363.2	21.3
n-hexa decyl iodide	749.2			746.0 (fixed)	725.3	21.7
iodo benzene		282.3 280.7	279.2	279.2 (fixed)	257.5	21.7
Trimethylene iodide		297.2		298.2 (fixed)	256.5	21.7
n-propyl iodoacetate		329.3		327.3 (fixed)	306.0	21.8
n-butyl iodoacetate		368.2		366.2 (fixed)	344.5	21.7

The average value is 21.5 for I-Br difference. Other values can be fixed with its help.

---

*P *Br is used to indicate parachor of bromo compounds fixed as above.

PARACHOR VALUE FOR CH_2 GROUP

Compound	Parachor	Diff.	CH_2 value.
Ethyl iodide	186.9		
		39.1	39.1
nipropyl iodide	226.0		
		38.9	38.9
n-butyl iodide	264.9		
		40.0	40.0
n-amyl iodide	304.9		
		40.1	40.1
n-hexyl iodide	345.0		
		39.5	39.5
n-heptyl iodide	384.5		
n-propyl iodoacetate	327.3		
		38.9	38.9
n-butyl iodoacetate	366.2		
i-butyl iodide	263.5		
		40.0	40.0
i-amyl iodide	303.5		
		Mean=	39.5

The value of CH_2 is not continuously increasing as we ascend the series.

Compound	Parachor	Diff.	CH_2 value
Ethyl chloride	151.6		
		39.6	39.6
n-propyl chloride	191.2		
		39.2	39.2
n-butyl chloride	230.4		
		39.8	39.8
n-amyl chloride	270.2		
		79.6	2 x 39.8
n-heptyl chloride	349.8		
		82.8	2 x 41.4
n-nonyl chloride	431.0		
i-propyl chloride	191.9		
		36.3	36.3
i-butyl chloride	228.2		
		40.9	40.9
i-amyl chloride	269.1		
n-decyl chloride	472.0		
		38.2	38.2
n-undecyl chloride	510.2		
		41.2	41.2
n-dodecyl chloride	515.4		
n-propyl chloroacetate	292.3		
		38.7	38.7
n-butyl chloroacetate	331.0		
Methylene dichloride	147.5		
		41.3	41.3
Ethylene dichloride	188.8		
		37.8	37.8
Propylene dichloride	226.6		
	Mean	=39.6	

Ethyl bromide	165.3		
		38.9	
n-propyl bromide	204.2		
		39.5	39.5
n-butyl bromide	243.7		
		39.6	39.6
n-amyl bromide	283.3		
		40.4	40.4
n-hexyl bromide	323.7		
		39.5	39.5
n-heptyl bromide	363.2		
		39.9	39.9
n-octyl bromide	403.1		
		40.9	40.9
n-nonyl bromide	444.0		
i-propyl bromide	205.4		
		36.3	36.3
i-butyl bromide	241.7		
		40.9	40.9
i-amyl bromide	282.6		
n-decyl bromide	472.0		
		38.2	38.2
n-undecyl bromide	510.2		
		41.2	41.2
n-dodecyl bromide	551.4		
Methylene di bromide	175.1		
		40.3	40.3
Ethylene di bromide	215.4		
		37.9	37.9
Propylene di bromide	253.3		
		Mean = 39.4	

Again, the value of CH_2 is not increasing steadily as we ascend the homologous series and is on average 39.5 and not 40.

The calculation of parachor value for CH_2 group can be obtained independent of other atoms from hydrocarbons. The results are as follows :-

Compound	Parachor B. A. R.	CH_2 diff.
Ethane	110.5	
		39.4
Propane	139.9	
		40.4
n-butane	190.3	
		2 x 40.05
n-hexane	270.4, 273.3	
		39.6
n-heptane	310.2,310.3 310.8	
		40.6
n-octane	350.6, 350.3 351.0	
		39.1
n-decane	429.7	
		16 x 40.7
n-hexacosane	1082.0	
		6 x 40.0
n-dotriacontane	1322.0	
		28 x 41.3
n-hexacontane	2480.0	

Again, the value of CH_2 does not seem to increase continuously.

The mean of ackyl benzenes determined by Vogel (*loc. cit.*) is 39.2 and is not continuously increasing in the homologous series.

Vogel (22) has calculated the parachor difference for CH_2 group in Methyl and Ethyl esters of saturated dicarboxylic asliphatic acids. (See results below)

Compound	Parachor	Diff. CH_2
Methyl malonate	283.0	
		38.3
Methyl succinate	321.3	
		40.1
Methyl gultarate	361.4	
		40.4
Methyl adipate	401.8	
		41.5
Methyl pimelate	443.3	
		41.1
Methyl suberate	484.4	
		40.2
Methyl azelate	524.6	
		Average=40.3

Compound	Parachor	Diff. for CH^2
Ethyl malonate	361.5	
		38.5
Ethyl succinate	400.0	
		39.6
Ethyl glutarate	439.6	
		40.6
Ethyl adipate	480.2	
		40.3
Ethyl pimelate	520.5	42.3
Ethyl suberate	562.8	
		2 x 40.5
Ethyl sebacate	643.8	
		Average=40.3

The differences for CH_2 group as shown above are not continuously increasing. At ethyl suberate there is a sudden rise in the difference which may be due to mistaken measurements. If we subtract corresponding methyl and ethyl malonates, succinates, etc., the following differences are observed:—

	Diff. 2 x CH
Malonates	2 x 39.3
Succinates	2 x 39.4
Glutarates	2 x 39.1
Adipates	2 x 39.2
Pimelates	2 x 38.6
Suberates	2 x 39.2
	Mean for CH^2=39.1

Methyl Esters of substituted malonic acid.

	Parachor	Diff. for CH^2
Malonate	283.0	38.9
Methyl malonate	321.9	38.3
Ethyl malonate	360.2	37.7
n-propyl malonate	397.9	
Dimethyl malonate	355.8	35.5
Methyl ethyl malonate	391.3	39.9
Methyl-n-propyl malonate	431.2	37.6
Ethyl-n-propyl malonate	468.8	36.3
Di-n-propyl malonate	505.1	

The results as given on the previous pages for CH_2 group in methyl and ethyl esters of saturated dicarboxylic aliphatic acids, show that the value of CH_2 group does not regularly increase as we ascend the homologous series. The mean observed is 40·3. We have calculated the mean parachor difference for Vogel's results for CH_2 group by subtracting corresponding ethyl and methyl esters of the same dicarboxylic aliphatic acids. The value comes out to be 39.1 and as before shows no regular increase. In hydrocarbons of aliphatic series the difference is again not varying regularly and approaches a mean value of 40 units for the parachor of CH_2 group.

Vogel and Donaldson and Quayle (3) have determined the parachor of alkyl benzenes. The mean difference for the parachor of CH_2 group is not varying regularly in the homologous series and has the mean value 39.2. The mean difference in homologous fluorides, iodides, bromides and chlorides is 39.9, 39.5, 39.6 and 39.4 respectively. In case of methyl esters of alkyl substituted malonic acid the difference for various series is 38.3, 37.3 respectively. Vogel has found a value of 37.3 for the parachor of CH_2 group by taking the difference of β-β substituted gluataric and corresponding malonic esters. It will be clear therefore that there is no use in fiinxg a value of 40 for CH_2 group since it varies from series to series. The value 40 is found mainly in hydrocarbons. But there are thousands of compounds of other homologous series where the value is much lower. We suggest therefore that Sugden's value of 39 and consequent value for other atoms are more useful for structural purposes.

The value of benzene ring according to Vogel is 1.4, according to Gibling it is zero and Mumford and Phillip value for the same is 0.8. It is impossible to distinguish between aromatic and aliphatic compounds since these values are of the order of error that is possible in determining parachor. In aliphatic compounds the value is always above 200 and as such, an error of 0.8 is certain. Further by attaching a special value for (OH) group because the values of alcohols are low, the most significant fact that there is hydrogen bonding could not have been discovered. The decrease is due to association by hydrogen bonding and is well established by Sidgwick (18) and others. Vogel's values fail to bring this point to notice. The values of Sugden, therefore, may still be retained without further criticism.

References

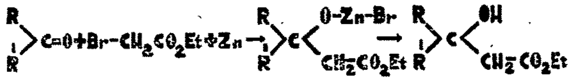
1. Bhagwat *et al.* 1945. *J. Indian chem. Soc.*, **22** :116. 221.
2. Bhagwat *et al.* 1948. ibid, **25** : 175.
3. Donaldson R. and Quayle. 1950. *J. Amer. chem. Soc.*, **72** : 35.
4. Edgar and Calingaert. 1929. *J. American chem. Soc.*, **51** : 1540.
5. Gibling. 1941. *J. chem. Soc.*, p. 229.
6. Gibling. 1942. *ibid.* p. 661 et seq.
7. Gibling. 1943. *ibid.* p. 146 et seq.
8. Gibling. 1944. *ibid.* p. 380 et seq.
9. Gibling. 1945. *ibid,* p. 236.
10. Harkins. Clark & Roberts 1920. *J. American chem.*, **42** : 700.
11. Harkins. 1921. *J. Amer. chem. Soc.*, **43** : 35.
12. Hunter & Maass. 1929. *J. Amer. chem. Soc.*, **51** : 153.
13. Mumford & Phillips. 1929. *J. chem. Soc.* p. 2112.
14. Mumford & Phillips. 1950. *ibid.* p. 75.
15. Richards, Speyers & Carver 1924. *J. chem. soc.*, **46** : 1196.
16. Schiff. 1884. *Annalen,* **223** : 47.
17. Schiff. 1884. *Gazzetta,* **14** : 368.
18. Sidgwick. 1930. *J. chem. Soc.*, p. 1461, 2027.
19. Sugden. 1924. *J. chem. Soc.*, **1125** : 1185.
20. Sugden. 1925. *ibid.* (**2**) : 1868, 2517.
21. Sugden. Parachor and Valency (Ronldedge 1930) p. 34-38.
22. Vogel. 1934. *J. chem. Soc.*, p. 333, 1758.
23. Vogel. 1938. *ibid.* p. 1336.
24. Vogel. 1939. *ibid.* p. 1862
25. Vogel. 1940. *ibid.* p. 171, 1528.
26. Vogel. 1943. *ibid* p. 16, 637.
27. Vogel. 1946 *ibid.* p. 133.
28. Vogel. 1948. *ibid.* p. 607 et seq. 1804 et seq.

REFORMATSKY'S CONDENSATION OF KETONIC ESTERS WITH HALO ESTERS

By M. B. ANTIA and R. KAUSHAL, *Chemistry Laboratory, Holkar College, Indore.*

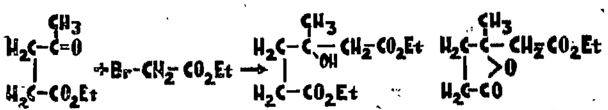
By Reformatsky's condensation of levulinic ester with halo-esters only lactonic esters were obtained. The condensation of acetoacetic ester with chloroformic ester gave product having composition of ∝-methyl ∝-hydroxy succinic ester.

In Reformatsky's reaction (1) ∝-bromo or ∝-iodo esters react with a carbonyl group of an aldehyde or a ketone in presence of zinc to form a β-hydroxy ester.



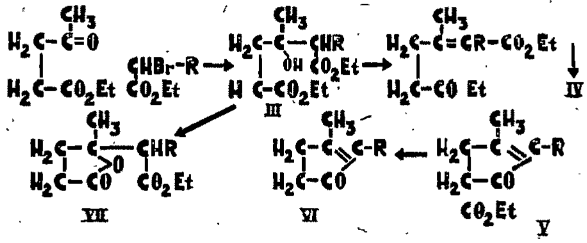
This reaction has been used for synthesis of citric acid by Lawrence(2) and of dl-camphoronic acid by Perkin (3) in which bromo acetic ester was condensed with oxalo acetic ester or dimethyl acetoacetic ester.

Bromo acetic ester has also been condensed with levulinic ester, a ketonic ester, the resulting hydroxy ester (I) cyclising to form the lactonic ester (II) (Duden and Freydag).(4)



I II

By carrying out Reformatsky's condensation between levulinic ester and an ∝-halo ester at higher temperature it is theoretically possible that water is eliminated from the hydroxy ester (III) during the process. The resulting unsaturated ester (IV) could then be made to undergo Dieckmann condensation to give an ∝-substituted cyclopentenone carboxylic ester (V) from which after hydrolysis and de-carboxylation the ∝-substituted cyclo pentenone (VI) would result.



This was actually realised by Standinger and Ruzicka (5) who obtained dihydrojasmone (VI, R-C_5H_{11}) by this process after working out Reformatsky's condensation at 150° between levulinic ester and ∝ -bromoheptoic ester.

We condensed ∝ -bromopropionic, ∝-bromo butyric and ∝-bromo lauric esters with levulinic ester at room temperature as well as high temperature and obtained in each case the corresponding lactonic ester(VII). Even when the reaction was carried out at 150° no unsaturated ester (IV) was obtained, the product being only the lactonic ester.

A considerable difference was noticed in the periods for completion of Reformasky's condensation with various ∝-halo esters. For whereas ∝-bromo acetic ester and ∝-bromo lauric ester each took about six hours for completion of reaction, with ∝-bromo propionic ester and ∝-bromo butyric ester the reaction was complete in half an hour.

On hydrolysis the lactonic esters gave the corresponding acids which are liquids, soluble in water and which distil with decomposition even under reduced pressure. The acids therefore could not be purified and analysed. The calcium salts of the acids are also soluble in water.

β-idio propionic ester and zinc did not condense with levulinic ester even when heated under reflux for several hours and even on adding copper powder as catyalyst.

The lactonic esters (VII) including those with a long carbon chain as in lauric ester, are liquids without any smell.

Chloroformic ester, which is the smallest halo ester with halogen directly connected to the ester group, does not seem to have been used in Reformatsky's reaction. We condensed it with aceto acetic ester in presence of zinc with copper powder as catalyst. The reaction was complete in about eight hours. The product proved to have the composition of -hydroxy α-methyl succinic ester as expected.

EXPERIMENTAL

Levulinic ester.—The crude levulinic acid derived from one kilo of cane sugar was esterfied with 500 c.c. of 90% alcohol. After keeping for two days the excess of alcohol was removed by distilling under reduced pressure and the residue was extracted with ether. After drying and removing the solvent 28 g. of levulinic ester b. p. 198° /714 m.m. was recovered.

α-bromo propionic ester.—On treating propionyl chloride (15g.) with bromine (29g.) in sunlight and esterifying with absolute alcohol the bromo ester was obtained, boiling at 124°/250 m.m. yield 14 g.

The lactonic ester (VII, $R = CH_3$) was prepared by condensing α-bromopropionic ester (8.1 g) with levulinic ester (7.2g) and zinc (3.3 g. B. D. H. Annalar) in dry benzene on water bath. The reaction was complete within half an hour. The resulting liquid was treated with 2N sulphuric acid and the benzene layer was washed with 10% sodium carbonate. After drying and distilling off the solvent the residue on distillation gave the lactonic ester as a pale yellow liquid (4.4 g) b. p. 160 /4 m.m. The lactonic ester dissolves in strong ammonia when kept over-night at ice temperature (Found C-59.4, H-8.0, $C_{10}H_{16}O_4$ requires C-60.0, H-8.0 per cent).

When the above reaction was carried out in boiling xylene (140°c) using the same proportions, the product on treatment as above gave 4 g. of liquid b. p. 156°/3 mm. (Found C = 59.6, H = 8.0). It is therefore the same lactonic ester as above.

β-iodo propionic ester (b. p. 196°/714 m.m.) did not react with levulinic ester at all under any of the above conditions. *α-bromo-n-butyric ester.*—n-butyryl chloride prepared from n-butyric acid and thionyl chloride after bromination in sunlight and subsequent treatment with alcohol gave the ester boiling at 106°/75 mm.

The lactonic ester (VII, $R=C_2H_5$) was prepared from 10 g. α-bromo-n-butyric ester, 7.2 g. levulinic ester and 3.3 g zinc in 30 c.c dry benzene. The reaction was vigorous and was complete in half an hour. On treatment of the mixture as usual the lactonic ester was obtained boiling at 183 —85°/6 m.m. yield 3.5 g. It is a colourless somewhat viscid liquid without any appreciable odour. (Found C—60.9, H—8.1, $C_{11}H_{18}O_4$ requires C=61.0, H=8.4 per cent).

α-bromo lauric ester was prepared by bromination of the acid chloride (from 20 g. of the acid and thionyl-chloride) on water bath for half an hour with 18g. bromine in sunlight in the presence of a trace of iodine. To complete the bromination the mixture was heated on a small naked flame for four hours when some carbonisation took place, and was esterified by pouring in absolute alcohol yield 16 g. b. p. 172°-74°/10 mm.

The lactonic ester (VII, $R=(CH_2)^9-CH_3$) was obtained by refluxing for six hours a mixture of α-bromolauric ester (15 g.) levulinic ester (7.2 g.) and zinc (3.3 g) dry benzene. After the usual treatment and removal of solvent the lactonic ester distilled at 162—64°/4 m.m. as a colourless liquid having no aroma. Yield 2.0 g. (Found C = 70.0, H=11.0, $C_{19}H_{34}O_4$ requires C = 70.0, H=10.4 per cent).

α-methyl α-hydroxy succinic ester.—A mixture of acetoacetic ester (Merck 6.5 g) and chloroformic ester (B. D. H. 5. 4 g) in dry benzene (30 c.c.) was heated under reflux with zinc (3.2 g) and reduced copper powder (0.2 g) for nearly eight hours. During the progress of the reaction about 1 g. more chloroformic ester was added. The contents were then treated as usual and after distilling off the solvent the hydroxy ester distilled at 156-60°/8 mm. as a colourless liquid without any smell. Yield 2 g.

(Found $C = 52.4$, $H = 7.4$, $C_9H_{16}O_5$ requires $C = 52.9$, $H = 7.8$ per cent).

REFERENCES

1. REFORMATSKY. 1887. *Ber. chem.*, **20** : 1210; 1895. *J. prakt. chem.*, **54** : 469.
2. LAWRENCE. 1897. *J. chem. Soc.*, 71 : 457.
3. PERKIN. 1897. *J. chem. Soc.*, **71** : 1173.
4. DUDEN and FREYDAG. 1903. *Ber. chem.*, **36** : 944.
5. RUZICKA *et al.* 1924. *Helv. chem. Acta*, **7** : 1245; (1933) *ibid.* **16** : 1208.

CONDENSATION OF β-3.4-METHYLENEDIOXY-PHENYLPROPIONAMIDE WITH BENZALDEHYDE, *o-m-* and *p*-METHOXYBENZALDEHYDES AND *o- m-* AND *p*-NITROBENZALDEHYDES

By T. George and P. I. Ittyerah, *Chemistry Department, St. John's College, Agra.*

The condensation of aldehydes with acid amides has been studied by a large number of workers. Often the reaction is brought about by merely mixing the aldehyde and the amide and then heating the mixture. In some cases condensing agents like hydrogen chloride, potassium hydroxide, potassium carbonate, dilute sulphuric acid, anhydrous sodium acetate, diethylamine and triethylamine have been used. Sometimes solvents like pyridine and alcohol have been used to keep the reactants in solution.

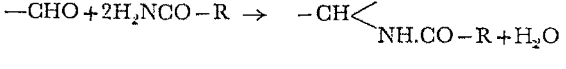
In this laboratory some workers (8) found a trace of pyridine a good condensing agent in some aldehyde-amide condensations. This has not proved to be useful in all cases. On the other hand in quite a number of cases better yields have been obtained when no condensing agent was used. (4)

The present paper deals with the condensation of β-3.4-methylenedioxy-phenylpropionamide, with benzaldehyde, the three mono-methoxybenzaldehydes and the three mono-nitrobenzaldehydes. The object of this work has been to study the course which these reactions took.

Regarding the course of the reaction, Titherly and Marples (10) suggest three different possibilities.

[a] $-CHO + H_2NCO-R \rightarrow -CH(OH)-NHCO-R$

[b] $-CHO + H_2NCO-R \rightarrow -CH{=}NCO-R + H_2O$

[c] 

$$-CHO + 2H_2NCO-R \rightarrow -CH\begin{cases} NH.CO-R \\ NH.CO-R \end{cases} + H_2O$$

where R is the alkyl or aryl radical in the acid amide. In the first type of reaction (a) the simple aldol condensation takes place, in the second type (b) an arylidene or alkylidene mono-amide is formed, and in the third type (c) an arylidene or alkylidene bis-amide is formed. All the three types have been investigated by earlier workers. (1, 2, 3, 5, 6, 7, 9)

Thus the product in any case may be one of the three types mentioned or a mixture of two or more. In the experiments described in this paper the first type of reaction is ruled out as there was copious evolution of water vapour during heating. The other two types of products have been obtained. From the 'Table' given at the end certain conclusions may be drawn. In the case of benzaldehyde, though the aldehyde and the amide were mixed in various molecular proportions (1 : 1 mol. or 1 : 2 mol.) the product has always been benzylidene-bis-β.3. 4-methylene-dioxy-phenylpropionamide. On the other hand with *o*-methoxy-benzaldehyde and *o*-nitrobenzaldehyde the products were the corresponding benzylidene-mono- β.3.4-methylenedioxy-phenyl-propionamide. With the *meta* and *para* isomers of these aldehydes both the bis and mono type products were formed depending on the quantity of the amide used (Refer 'Table').

EXPERIMENTAL

Preparation of β-3.4-Methylenedioxy-phenylpropionamide

The method followed was almost the same as the one recommended by Raman and Dey (9). In the first stage 3.4-methylenedioxy-cinnamic acid was prepared by condensing piperonal with malonic acid in the presence of a trace of pyridine. Then 3.4-methylenedioxy-cinnamic acid was reduced by sodium amalgam and converted to β.3.4-methylenedioxy-phenyl propionic acid. The acid was then converted to its acid chloride by treatment with thionyl chloride. The acid chloride was converted to the acid amide by pouring the acid chloride into liquor ammonia. The amide separated as a white crystalline solid and melted at 122° C.

Condensation of β.3.4-Methylenedioxy-phenylpropionamide with aldehydes

The general procedure has been to take the aldehyde and the amide either in 1:1 molecular proportion or in 1:2 molecular proportion and then heat the mixture for 4 to 6 hours at 100° to 105° C. After heating the products were allowed to cool and then extracted with ether. This treatment removed all the unreacted aldehyde. Then he residue was repeatedly washed with hot alcohol and chloroform. This removed the unreacted amide and other impurities leaving the pure product. The product could be further purified by recrystallisation from glacial acetic acid. Separation of the mono and bis products could be done by fractional crystallisation from glacial acetic acid.

Each product thus obtained was analysed and its identity established. The mono products decolourised both bromine water and alkaline potassium permanganate solution. The molecular weight of each substance was determined by Rast's method. The following products were obtained and the 'Table' at the end gives the experimental conditions observed.

1. *Benzylidene-bis β 3.4-methylenedioxy-phenylpropionamide.* Melting point 225^0. Found Nitrogen=6·11%; C_{27} H_{26} O_6 N_2 requires 5.91%. Found M.W.=478 : C_{27} H_{26} O_6 N_2 requires 474.

2. *O-Methoxybenzylidene-mono-β.3.4-methylenedioxy-phenylpropionamide.* Melting point 193^0. Found Nitrogen=4·14% : C_{18} H_{17} O_4N requires 4.5%. Found M. W.=320 : C_{18} H_{17} O_4 N requires 311.

3. *m-Methoxy-benzylidene-bis-β.3.4-methylenedioxy-phenylpropionamide.* Melting point 195^0. Found Nitrogen 5.62% =: C_{28} H_{28} O_7 N_2 requires 5.56%. Found M. W.=512 -: C_{23} H_{28} O_7 N_2 requires 504.

4. *p-Methoxybenzylidene-bis-β-3.4-methylenedioxy-phenyl-propoionamide.* Melting point 186^0. Found Nitrogen=5.78% : C_{23} H_{33} O_7 N_2 requires 5.56%. Found M. W.=503 : C_{28} H_{38} O_7 N_2 requires 504.

5. *p-Methoxybenzylidene-mono β -3.4-methylenedioxy-phenylpropionamide.* Melting point 208^0 Found Nitrogen=4.66% : C_{18} H_{17} O_4 N requires 4.5%. Found M. W.=315 : C_{18} H_{17} O_4 N_2 requires 311.

6. *o-Nitrobenzylidene-mono-β-3.4-methylenedioxy-phenyl-propionamide.* Melting point 204^0. Found Nitrogen=8.4% : C_{17} H_{14} O_5 N_2 requires 8.59%. Found M. W=320 : C_{17} H_{14} O_5 N_2 requires 326.

7. *m-Nitrobenzylidene-bis-β-3.4-methylenedioxy-phenylpropionamide.* Melting point 228^0. Found Nitrogen=8.25% : C_{97} H_{25} O_8 N_3 requires 8.09%. Found M. W.=523 : C_{27} H_{25} O_8 N_3 requires 519.

8. *m-Nitrobenzylidene-mono-β-3.4-methylenedioxy-phenylpropionamide.* Melting point 223^0. Found Nitrogen=8.92% : C_{17} H_{14} O_5 N_2 requires 8.59%. Found M. W.=333 : C_{17} H_{12} O_5 N_2 requires 326.

9. *p-Nitrobenzylidene-bis-β-3-4-methylenedioxy-phenylpropionamide.* Melting point 212^0. Found Nitrogen=8.12 % : C_{27} H_{25} O_8 N_3 requires 8.09%. Found M. W.=524 : C_{27} H_{25}. O_8 N_3 requires 519.

10. *p-Nitrobenzylidenemnoo β-3.4-methlenedioxy-phenylpropionamide.* Melting point 215^0 Found Nitrogen=8.5% C_{17} H_{14} O_5 N_2 requires 8.59%. Found M. W.=324 : C_{17} H_{14} O_5 N_2 requires 326.

Table showing the experimental conditions and the yield [per cent] of products.

Amide	Aldehyde	Cond. Agent	Mol. prop.	Temp.	Time	% Yield of produtcts	
						Bis	Mono.
3.4—Methylene-dioxy-phenyl-propionamide.	Benzaldehyde.	Nil.	1:1	105°	4 Hrs.	62.6	
,,	,,	,,	2:1	,,	6 ,,	62.6	
,,	,,	pyridine	2:1:0.15	,,	4 ,,	63.3	
,,	,,	Nil	1:1	,,	4 ,,	24.1	
,,	*o*-Methoxy benzaldehyde	,,	,,	,,	,,		18.9
,,	,,	,,	2:1	,,	,,		20.2
,,	*m*-Methoxy benzaldehyde	,,	2:1	,,	,,	17.9	
,,	,,	,,	1:1	,,	,,	18.6	
,,	*p*-Methoxy benzaldehyde	,,	2:1	,,	,,	56.1	
,,	,,	,,	1:1	,,	,,		45.4
,,	*o*-Nitro-benzaldehyde	,,	1:2	,,	,,		84.8
,,	,,	,,	1:1	,,	,,		47.2
,,	*m*-Nitro-benzaldehyde	,,	2:1	,,	,,	49.3	
,,	,,	,,	1:1	,,	,,		21.5
,,	*p*-Nitro-benzaldehyde	,,	2:1	,,	,,	53.3	
,,	,,	,,	1:1	,,	,,		35.3

SUMMARY

β-3.4-Methylenedioxy-phenylpropionamide was prepared and condensed with benzaldehyde, the three mono-methoxybenzaldehydes and the three mono-nitrobenzaldehydes. Benzaldehyde gave benzylidene-bis-3.4-methylenedioxy-phenylpropionamide. *o*-Methoxybenzaldehyde and *o*-nitrobenzaldehyde gave the corresponding benzylidene-mono-β-3.4-methylenedioxy-phenylpropionamides. *m*- and *p*-Methoxy and Nitrobenzaldehydes gave mixtures of the mono-amide and the bis-amide.

REFERENCES

1. CEBRIAN. 1898. Ber., **30** : 1952.
2. EINHORN and LADISCH. Ann. **343** : 265.
3. HOFMANN and VICTOR MEYER. Ber., **25** : 212.
4. ITTYERAH, P. I. and K. C. PANDYA. 1942. *Proc. Indian Acad. Sci.*, 15(1)(A)16.
5. JACOBSON. Ann., **157** : 245.
6. MEHRA, R. K. and K. C. PANDYA. 1938. *Proc. Indian Acad. Sci.* **7**(6) : 376.
7. NOYES. 1933. *J. American. chem. Soc.*, **55** : 2493.
8. PANDYA, K. C. and T. S. SODHI. 1938. *Proc. Indian Acad. Sci.*, **7**(6) : 376.
9. RAMAN, M. S. V. and B. B. DEY 1937 Laboratory Manual of Organic Chemistry, p. 100.
10. TITHERLY and MARPLES. 1908. *J. chem. Soc.*, **93** : 1933.

STUDIES OF JOSHI EFFECT IN IODINE VAPOUR UNDER ELECTORDELESS DISCHARGE

By A. P. SAXENA, *Reader in Physics, Holkar College, Indore* and C. N. RAMACHANDRA RAO, *Research Scholar, Indian Institute of Technology, Kharagpur.*

ABSTRACT

Detailed investigations on the phenomenon Δi were made in I_2 vapour enclosed in discharge tubes of different lengths (l) excited by alternating potentials (V) applied externally by making contact with metallic electrodes of diameter (d). The current (i) was investigated by a C. R. O. and a galvanometer actuated by a diode. Threshold potential (Vm) which marked the change of the non-self-maintained to self-maintained discharge increased with l and unaffected by d. Increase of both l and d enhanced i. Below Vm, a very large positive effect characterised by initiation of h. f. pulses on the current trace was noticed. This inception of $+\Delta i$ was apparently not instantaneous and required a time period of ~ 3 sec. after the act of irradiation. With increase of V $+\Delta i$ decreased and changed sign to give $-\Delta i$. Thus e. g., for $l=77$ mm., $\%\Delta i$ was $+\Delta i$ 83 at 0.8kV and —100 at 0.93 kV. Increase of l and an opposite change of d favoured $-\Delta i$ and inhibited $+\Delta i$. At a fixed l and d, while Vm and i decreased, $-\Delta i$ increased numerically, with ageing; $+\Delta i$, however, was disfavoured. Irradiation in part of different electrodes (H. T. and L. T.) and discharge space showed that $-\Delta i$ was maximum only when H. T. was illuminated, indicating thereby that the electrode surface primarily that of the cathode was the chief determinant of Δi (Proc. Ind. Sci. Cong., Chem. Sec., 1953, Abs. 98) 15.

INTRODUCTION

Studies in Joshi Effect, (6) *viz.*, Δi an instantaneous and reversible photo-variation of discharge current i flowing through a gas subjected to an alternating discharge, revealed its occurrence in many gases and vapours of elements or compounds or their mixtures. Joshi Effect in iodine had been studied in ozonisers, semi-ozonisers, sleeve discharge tubes etc., by other workers (2, 5, 11, 13) and so, the phenomenon was investigated in iodine filled cylindrical discharge tubes with plane parallel metal electrodes externally in contact with the flat ends of the tubes, following earlier workers like Harries and Engel, Agashe, and Marathe (4, 1, 10, 11), who worked in similar discharge tubes in other gases. Detailed investigations now made on the dependence of Joshi Effect on the length of the discharge tubes and diameter of the electrodes, revealed that even 100% current dimunition could be obtained under favourable circumstances. Positive Joshi Effect

$+\Delta i$ *viz*., a photo-increase in *i* was observed at potentials just lower than the threshold potential Vm[6] at which the vapour breaks down as a dielectric and indications of slight positive effect at high voltages $V \gg Vm$ were obtained when lengths of the discharge tubes were small. Study of Joshi Effect under partial irradiation of the discharge tube was made by exposing the electrodes and the central part of the tube, to light separately. The observations show that the seat of Joshi Effect is in the electrode layers primarily that of the cathode as suggested by Joshi (6).

EXPERIMENTAL

The general arrangement of apparatus and the electrical circuit are shown in the Fig. 1. Cylindrical discharge tubes of various lengths made from soft soda glass were cleaned, dried and heated to $\sim 400^\circ C$ to remove wall-absorbed impurities. Solid iodine, about 0.5 gm was introduced into each tube which was next evacuated completely on a Topler pump and a small quantity of I_2 vapour was also removed by warming the tube.

The tubes were excited by single phase alternating potentials

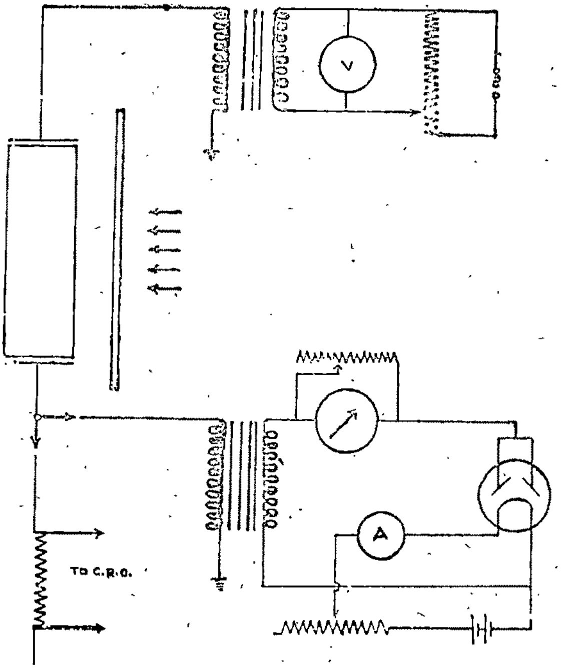


Fig.1. General arrangement of apparatus and electrical circuit.

V, of 50 cycle frequency obtained from a rotary converter working at 220 volt d. c. mains and stepped up by a high tension transformer (of ratio 1 :133). Two copper electrodes were kept externally in contact with the flat ends of the discharge tube, one of them being connected to the H. T. terminal of the transformer and the other earthed through the primary of a Bell transformer. We call the earthed electrode as the L. T. electrode and the other connected to the transformer secondary as the H. T. electrode of the discharge tube. In the secondary of the Bell transformer is connected a double diode detector for a. c. rectification. The discharge current i, was investigated by a C. R. O. and a sensitive galvanometer, when the discharge tube was screened from light (iD) and also when exposed (iL) to 200 watt 220 volt incandescent bulb, which was enclosed in a wooden box fitted with a pulley operated shutter. From the values of iD and iL the net effect $\triangle i = (iD - iL)$ and its relative value $\% \triangle i = \frac{100 \times \triangle i}{iD}$ were calculated

The influence of the following factors on the Joshi Effect, discharge current and threshold potential were investigated in detail—(i) Ageing,(6) (ii) Length of the discharge tube (l) (iii) Diameter of the electrodes (d). and (iv) Influence of partial irradiation. A few of the relevant observations have been reproduced in the following tables. Typical current oscillograms in dark and under light at a few voltages are returned in fig. 2.

Below the threshold potential, Vm, which marked the change of the non-self-maintained to self maintained, discharge an appreciable positive effect was observed, which was characterised by the initiation of h. f. pulses on otherwise smooth sinusoidal wave form. (Oscillogram I., Fig. 2.) The range of voltages over which this occurred was narrow and $+\triangle i$ decreased with further increase in V and finally passed over to the negative effect,—$\triangle i$ viz., a photo-decrease in discharge current.

Both positive and negative effects are obtained simultaneously in the current structure as revealed by the oscillograms above Vm. When the tube was irradiated, the amplitude of some h. f. pulses were reduced, while a large number of new pulses also appeared. (Oscillogram II, Fig. 2.). As the exciting potential was increased the $\%\Delta i$ progressively diminished, becoming zero at high potentials.

TABLE I

(i) Influence of Tube Length on Joshi Effect
Temp=35^{0}c, Electrode diameter=1.96 cm.

Applied Voltage in kV		Length of the tube		
		.15 mm	28.5 mm	77 mm
0.8kv	$\%\Delta$	-50	-75	+83
	i_D	17	25	6
0.93	i_L	8	6	0
	$\%\Delta i$	-50	-76	-100
	i_D	18	30	9
1.06	i_L	9	5	0
	$\%\Delta i$	-50	-83	-10
	i_D	20	36	11
1.33	i_L	10	8	1.5
	$\%\Delta i$	-50	-77	-86
	i_D	35	38	52
4.65	i_L	35	37	47
	$\%\Delta i$	0	-3	-10
	i_D	85	98	105
6.65	i_L	86	100	102
	$\%\Delta i$	+1	+2	-3

(ii) Influence of Electrode Diameter on Joshi Effect.

Diameter of electrodes Tube length=63.5 mm temp=35^{0}c

		2.72 cm	1 96 cm	1.23 cm
	i_D	2	2	2
1.06	i_L	5	0	0
	$\%\Delta i$	+150	-100	-100
	i_D	14	7	5
1.33	i_L	10	4	0
	$\%\Delta i$	-25	-43	-100
	i_D	55	37	22
5.32	i_L	54	35	20
	$\%\Delta i$	-2	-6	-10
	i_D	225	138	97
9.31	i_L	225	138	95
	$\%\Delta i$	0	0	-2

(Current multiplication factor.........1.278×10-7 amps)

TABLA II

Results of Partial Irradiation

Tube length—92mm. Electrode diameter—1.96cm. Temp.—35c

Applied voltage in kv.	($\%\Delta i$) Irradiation of the entire tube.	H. T. alone.	L T. alone,
1.19	+400	+400	0
1.59	—33	—33	0
1.99	—34	—32	—3
2.66	—44	—40	—3
3.99	—17	—17	0

DISCUSSION

Occurrence of Joshi effect in a simple glass cylindrical discharge tube filled with I_2 vapour establishes the universality of the phenomenon. The only satisfactory surface theory is the one simultaneously proposed by Harris and Engel, (19, 4) and Ramiah, and extended by one of the authors of this paper (A. P. S.). The surface molecules held by Van-der-Waal's forces dissociate under light to yield electronegative atoms or/and radicals which reduce the secondary emission to give $-\Delta i$, positive effect being due to the photo-ionisation of pre-excited particles on or/and in the vicinity of the cathode.

Below Vm, the discharge conditions are of the Geiger Region (non-self-maintained) of the discharge(7). Irradiation initiates the shorter pulses by introducing electrons into the system due to photo-ionisation of pre-excited particles on or/and in the vicinity of the cathode (oscillogram I.). The electrons produce a set of avalanches and hence current is greatly increased . This is referred as the +effect. The act of irradiation transforms a non-self-maintained discharge into a self-maintained discharge.

At Vm, the threshold potential for the transformation of a non-self-maintained discharge into a self-maintained one on account of the various β processes at work. The effect of light is to decrease the current. Oscillographic studies (oscillogram II) have shown that the external light inhibits markedly the longer pulses. The decrease in the number of longer pulses, was accompanied by the simultaneous production of shorter pulses. This indicated the co-occurrence of + and— effects.

The longer pulses produced are due to large number of avalanches created by fast moving electrons emitted from the cathode by γ and n6g processes. The surface molecules held by Van-der-Waals forces dissociate under light to yield electronegative atoms or/and radicals which reduce the secondary emission and hence longer pulses to give $-\Delta i$

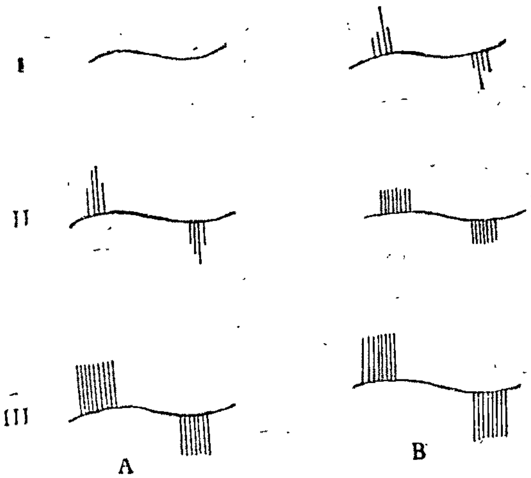


Fig. 2. Typical current oscillograms.

Enhanced *V* decreased the number of longer pulses and enhanced the shorter ones, the number of these last increases progressively with *V* (oscillogram III). The shorter pulses are unaffected by light and hence reduced Joshi effect $(-\Delta i)$ may be expected at progressively higher potentials. The favourable influence of enhanced *V* on the production of shorter pulses indicated that unlike in a d. c. discharge in non-heterogenous gases, photo-ionisation in the gas phase was a significant secondary mechanism, for the maintenance of a low frequency electrodeless discharge (17).

From the tables given above it is evident that Joshi Effect depends on the length of the discharge tube (l) and the diameter of the electrodes (d). The magnitude of $-\Delta i$ increased with increase in (*l*) and decrease in (d) while $+\Delta i$ seemed to be disfavoured.

The simple behaviour that $-\triangle i$ and i increased with (l) could not be reproduced with large tube lengths (of. Table 2). There were indications of small $-\triangle i$ at high V when tubes of small length ($l=15$mm, 28.5mm) were used. The discharge was more along the walls of the tube when (l) was small and also when (d) was great, as could be made out by the observation of brighter glow along the walls of the tube, than in the gas phase. The glow, however, was always bright near the electrodes.

Work with ozonisers semi and full (14) have shown little or no positive effect below Vm. It appears to be very common with sleeve discharge tubes and cylindrical discharge tubes with external electrodes. The essential difference between an ozoniser and a cylindrical discharge tube is that in the former the entire glass surface is either positively or negatively charged while in the latter most of the glass surface is not in contact with the electrodes. The surface therefore shall acquire a charge due to electrons diffusing, which is not possible in ozonisers. Hence surface charges, (both external and internal) appear to play a very significant role in cylindrical tubes and sleeve discharges. (3) On account of the erratic behaviour of the effects of surface charges, the authors are greatly doubtful if observations could be exactly reproduced in such tubes at a later date, while in ozonisers there is practically exact reproducibility of observations at a later time.

On irradiation, these surface electrons shall be released; those near the cathode fall region shall start new avalanches and shall increase the discharge current. This shall be over and above the increase in current due to photo-ionisation of the pre-excited gas particles on or at the vicinity of the cathode. Electrons released in other parts of the discharge tube may affect only slightly the discharge conductivity, since they shall not possess sufficient energy to produce ionisation by collisions. However the net result of all these factors is a greatly enhanced conductivity under irradiation of the discharge tube.

$-\triangle i$ shall also be likewise affected. The exact nature of their (surface charges) influence on $-\triangle i$ is difficult to predict on account of our limited knowledge about these surface charges and about the forces which bind them to the glass walls.

The results of partial irradiation of the discharge tube are significant and throw much light on the mechanism of the discharge and the Joshi Effect. Joshi Effect was maximum only when the H. T. electrode layer was illuminated. Irradiation of the L. T. electrode layer was less effective while no change was observed when the central portion of the tube was exposed to light. Similar results have been obtained by other workers. Marathe (10, 11) has observed maximum effect when the H. T. electrode was irradiated in a Neon Geissler tube. Khastgir (8) Setty (9) and others using sleeve discharge tubes have reported that the maximum effect is observed when the electrode regions are irradiated. In hydrogen Geissler tubes and discharge tubes C. N. Rao and Cabbinavar have observed the maximum effect near the H. T. electrode regions. These results are in contradiction to the findings of Agashe(1). As has been well pointed out by Khastgir,(8) the results of Agashe may be erroneous, consequent to the use of a small discharge tube, the light reaching the electrodes was unavoidable due to internal reflections. The difference in the effects at the two electrodes may be probably due to the difference in the wall charges on the surface of the discharge tube near the electrodes as proposed by Khastgir *et al.* (8,19)

The negative Joshi Effect has been shown to be (*vide Supra*) due to the inhibition of secondary emission from the cathode due to irradiation. It therefore readily follows that the irradiation of electrodes (especially the cathode) is responsible for $-\triangle i$. It is therefore essentially a surface phenomenon, as suggested by Joshi, (6) the volume or bulk of the gas playing little part in its production.

Our grateful thanks are due to Dr. S. S. Joshi, D. Sc., F. N. I., of Banaras, for valuable guidance and Dr. W. V. Bhagwat, D. Sc., Holkar College, Indore for keen interest in the progress of the work.

References

1. Agashe. 1951. *J. chem. Phys.*, **19** : 8, 1002.
2. Deshmukh. 1949. *Proc. Indian Acad. Sci.*, **29** : 243.
3. Francis. "Fundamentals of discharge tube circuits" Methuens' series p. 100.
4. Harries and Engel. 1951. *Proc. Phys. Soc.*, (A)**64** : 916.
   1951. *J. chem. Phys.*, **19** : 514.
5. Jatar. 1950. *J. Sci. industr. Res.*, **9**(B) : 283.

6. JOSHI. 1939. *Curr. Sci.*, **8** : 548.
1943. *Presid. Addr. Proc. Indian Sci. Cong. chem. Sec.*
1944. Nature 154, 147.
1945. *Proc. Indian Acad. Sci.*, **14** : 317.
7. KORFF. 'Electron and Nuclear counters" I. Van. Norstrand Co. (1948).
8. KHASTGIR. 1952. *J. chem. Phys.*, **20** : 1952.
9. LOEB. 'Fundamental processes in Electrical discharge in gases'. John Wiley & Co. 1939.
10. MARATHE and KULKARNI. 1952. *Proc. Indian Sci. Cong. Phy.*, (A) **36.**
11. MARATHE *et al.* 1951. *Ibid.* (A) **26.**
12. RAMAIH. 1951. *J. industr. Res.*, **10**(A) : 182.
13. SAXENA *et al.* 1951. *Proc. Indian Sci. Cong. chem.*, (A)23.
14. SAXENA. 1951. *J. Indian chem. Soc.*, **28** : 239.
15. SAXENA and RAO. 1953. *Proc. Indian Sci. Cong. chem.* (A) 98.
16. SAXENA *et al.* 1952. *J. chem. Phys.* **20** : 1342.
17. SAXENA. 1953. *J. chem. Phys.*, **21** : 1953.
18. SAXENA *et al.* 1953. *J. Sci. industr. Res.* **12**(A) : 130.
19. SETHY *et al.* 1952. *Proc. Phys. Soc.* (B)**65** : 823.

ACTIVITY OF MICRO-ORGANISMS AFFECTING NITROGEN, PHOSPHORUS AND CARBON CHANGES IN SOIL

By A. N. Pathak, M. Sc., Ph. D., *Soil Microbiologist Bihar, Sabour.**

Introduction

The changes nitrogen, phosphorus and carbon undergo in soil have been accepted beyond doubt to be closely associated with microbial activity of the soil. The carbon compounds are used by micro-organisms as sources of energy and carbon for structural purposes or for building up of microbial cells. In view of the fact that microbial cells contain between 3-15% of nitrogen, large quantities of this element have to be assimilated. Phosphorus is utilised by all micro-organisms either in the form of simple inorganic compounds or is obtained from complex organic substances in the process of their decomposition.

The decomposition of organic matter in soil has received much attention. It is the purpose of this paper to report the relationship of nitrogen, phosphorus and carbon changes in soil to the microbial activities as determined by pot-culture experiment.

Historical

Available data regarding the relationship of nitrogenous fertilizer to the microbial activity of the soil are meagre. In 1928 Winogradsky and Ziemiecka (55) concluded that the addition of nitrogenous fertilizers to the soil causes a reduction in the activity of azotobacter presumably on account of the presence of available nitrogen. It was confirmed by Ziemiecka (56). On the other hand Vandecaveye and Villanueva (51) observed greater nitrogen fixation in soil samples that had received available nitrogen. They also observed that the activity of azotobacter was stimulated when one percent filter paper was added which resulted in increased amount of fixed nitrogen.

---

*Now Assistant Agricultural Chemist, Govt. Agricultural College, Kanpur, U. P.

Available evidence regarding the fate of phosphorus, however, indicates that considerable mobilization of phosphorus occurs during decomposition of organic matter in soil by micro-organisms. Dushechkin (13) claims that in addition to physico-chemical absorption of phosphorus, a biological absorption occurs during decomposition of organic matter by micro-organisms. Stoklasa (42) reported that bacterial cultures growing on media supplied with various insoluble phosphates may assimilate as much as 25% of the total phosphorus. Schreiner (37) was led to believe that micro-organisms elaborate nucleo-protein from other nitrogenous and phosphatic compounds including inorganic phosphates naturally occurring in soils. Whiting and Heck (51) suggested that during the decomposition of materials with high cellulose content in compost, phosphorus might be added to advantage; it becomes conveted into organic complexes. Demolon and Barbier (12) reported that when organic matter is mineralized, phosphates may be reassimilated by micro-organisms and synthesized into microbial cells in the presence of available energy. Tam and Magistad (44) found a decrease in soluble phosphorus during the decomposition of organic matter; the available phosphorus was eventually released and attributed to the utilization of the element by micro-organisms during active period of organic matter decomposition. Lockett (23), during the decomposition of organic matter in soil, observed that inorganic phosphorus is converted into organic phosphorus through assimilation by micro-organisms. On further decomposition of organic matter, the phosphorus is again liberated into inorganic state; this appears to be associated with the disintrigration of the microbial cells.

It is of interest to note, however, that Smith and Humfeld (40) noted that during decomposition of green manure the numbers of bacteria followed carbon dioxide production curve. Allen, Abel and Magistad (2) also observed a positive correlation between numbers of bacteria, losses in organic matter and carbon dioxide production. Furthermore Smith & Brown (39) and Corbet (10) reported that carbon dioxide evolution from a soil resembled the type of carbon dioxide curve observed in pure culture of bacteria. It would seem, therefore, that increased carbon dioxide production would be paralleled to an increase in the numbers of micro-organisms. Vandecaveye and Villanueva (51) observed that in presence of available nitrogen the fungi and bacteria were first to make use of the readily available organic compounds either originally present in the soil or supplied by additions of carbonaceous organic materials. Vandecaveye and Allen (48) noticed that repeated application of straw and nitrogenous fertilizers to the field did not affect carbon dioxide evolution and microbial activity to any appreciable extent. Furthermore Vandecaveye and Baker (49) were led to believe that increased rate of carbon dioxide evolution did not coincide with increased microbial numbers. They observed that the rate of carbon dioxide evolution and nitrate accumulation in identically treated samples of the two soils was not proportional to the bacterial population of the samples. On the other hand Bodily (5) observed that the numbers of bacteria were affected most by the nature of the plant material and by the application of lime. His observations showed that the evolution of carbon dioxide was closely correlated with fluctuations in numbers of bacteria.

PLAN OF EXPERIMENT

The experiment was conducted in glazed earthenware pots using 7 kg. soil, which was taken from the surface 6″ of the cultivated field, dried in air and then passed through 3 mm. sieve. The following are the analytical values at start :—

1.	Organic carbon	—	0.493%
2.	Total nitrogen	—	0.0582%
3.	Nitrate nitrogen	—	15.1 ppm.
4.	Total phosphorus	—	0.0463%
5.	Available phosphorus	—	0.93 mg%
6.	Number of fungi	—	14 thousand per gram dry soil.
7.	Number of actinomyces	—	234 thousand per gram dry soil
8.	Number of bacteria	—	4.19 million per gram dry soil
9.	Carbon dioxide evolved	—	4.6mg/100 gm soil in 24 hrs.

The results incorporated in the paper are the mean of the following treatments made in four replications :—

1—Control	—	No treatment.
2—N′ and N″	—	100 and 200 ppm. nitrogen as ammonium sulphate respectively.
3—P′ and P″	—	50 and 100 ppm phosphorus as super phosphate respectively.
4—C′ and C″	—	0.0 5 and 0.2 percent carbon as filter paper respectively.

Soil mositure of the pots was kept at 50% of water holding capacity of the soil. During sampling the soils were removed from the pots, thoroughly mixed, sampled, and replaced.

BACTERIOLOGICAL TECHNIQUE AND METHOD OF ANALYSES

Bacteriological technique adopted and the media used for counting of fungi, actinomyces and bacteria were the same as explained in detail by Pathak (31).

The following analytical methods were adopted :—

1—Organic carbon was determined by Walkley and Black (1934) method.
2—Total nitrogen was determined by Kjeldabl method modified by Bal (1925).
3—Nitrate-nitrogen was determined by Harber's (1924) phenoldisulphonic acid methods.
4—Total phosphorus was determined by A. O. A. C. (1948) Method.
5—Available phosphorus was determined by Troug's (1930) Method.

Experimental Results

TABLE I

ORGANIC CARBON PERCENT IN THE TREATED SOILS
(Original Organic Carbon=0.493%)

Treatments—	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week
Control	0.491	0.488	0.439	0.487	0.485	0.484	0.484	0.482
	0.491	0.483	0.478	0.474	0.472	0.470	0.468	0.467
N''	0.489	0.481	0.476	0.472	0.469	0.467	0.465	0.463
P'	0.491	0.489	0.486	0.484	0.485	0.481	0.478	0.477
P''	0.490	0.487	0.484	0.484	0.481	0.478	0.478	0.476
C'	0.539	0.527	0.520	0.517	0.515	0.513	0.510	0.506
C''	0.693	0.682	0.675	0.671	0.668	0.665	0.662	0.659

A perusal of the data in table 1 indicates a tendency towards the loss of organic carbon in all the treatments. It was rapid in beginning but slowed down afterwards. This may be attributed to the increased microbial activities and to the utilization of easily oxidisable organic matter as a source of energy. There appears little difference in carbon oxidation with the two levels of nitrogen studied. A similar phenomenon was observed with phosphorus treatments. This may be due to the limited supply of easily available carbon from the soil for the microbial activity. The loss of carbon was observed to be more with the lower dose of filter paper treatment than with the higher dose. The values of carbon dropped down from 0.543 to 0.506 and from 0.693 to 0.659 gms, which come to 6.8 and 4.9 percent of the organic carbon at start with C′ and C″ treatments respectively. Broadbent and Bartholomew (7) also observed that the decomposition of straw in soil was inversely related to the quantity of straw added.

Table II

TOTAL NITROGEN PERCENT IN THE TREATED SOILS
(Original Total nitrogen—0·058%).

Treatments	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week
Control	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
N′	0.068	0.067	0.065	0.064	0.063	0.063	0.062	0.062
N″	0.078	0.076	0.074	0.072	0.071	0.070	0.069	0.068
P′	0.058	0.059	0.059	0.060	0.060	0.06	0.061	0.062
P″	0.058	0.059	0.060	0.060	0.061	0.061	0.061	0.062
C′	0.058	0.059	0.060	0.061	0.061	0.062	0.062	0.062
C″	0.058	0.059	0.061	0.062	0.062	0.063	0.064	0.064

From the data in table 2 it is observed that there was a loss of total nitrogen from 0.068 to 0.062 and from 0.078 to 0.068 gms. with N′ and N″ treatments, which respectively come to approximately 9.5 and 12.8% nitrogen of the total nitrogen at start. According to Bonazzi (6), Azotobacter may fix nitrogen in the absence of such fixed nitrogen and act as a "denitrifying" organism in the presence of available nitrogen compounds. Lipman (22) reported that ammonium and peptone are available nitrogen compounds like nitrates and one half milligram of nitrogen in an available form is sufficient to inhibit completely the fixation process. Pathak (31) observed a loss of 5.6 percent nitrogen of the total nitrogen at start with the application of ammonium sulphate on a different type of soil and attributed to volatalization of ammonia under tropical conditions. These results need confirmation and elucidation.

With P′ and P″ treatments there appears fixation of nitrogen from the atmosphere. There is no appreciable difference in the amount of nitrogen fixed with the two levels of phosphorus. The figures for total nitrogen increased from 0.058 to 0.062 and from 0.058 to 0.062 gms, which work out to be 5.4 and 6.8 percents of the total nitrogen at start with P′ and P″ treatments respectively. This is because phosphorus compounds greatly accelerate the activities of Azotobacter, since they play an important role in its metabolism large quantities of the metal being required for the synthesis of the cells. This falls in line with the observations of Dzierzbicki (15) and Waksman (53).

There is an increase in the amounts of total nitrogen also with C′ and C″ treatments. The values for total nitrogen with C′ and C″ treatments increased respectively from 0.058 to 0.62 and from 0.058 to 0.064 gms which approximate to 7 and 10 percents of the total nitrogen at start. This falls in line with the observation of Dvorak and Hutchinson (14), who observed the utilization of cellulose by Azotobacter for nitrogen fixation. Krishna (21) also observed that nitrogen fixation by *Azotobacter chroococcum* in 100 C. C. mannitol media was doubled when cellulose was added.

TABLE III

NITRATE-NITROGEN IN PPM. IN THE TREATED SOILS.

(ORIGINAL NITRATE NITROGEN=15.1 PPM.)

Treatments	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week
Control	15.9	15.6	15.9	16.3	16.9	17.0	17.0	17.3
N'	59.7	60.3	40.3	35.9	31.2	30.3	12.7	17.3
N"	121.9	93.5	77.0	62.5	49.3	35.7	30.9	25.9
P'	20.4	21.9	22.5	24.1	26.6	27.5	29.5	30.3
P"	20.7	23.3	23.3	24.5	27.7	29.5	30.9	31.3
C'	...	...	...	1.9	2.2	3.9	8.7	10.4
C"	...	...	...	...	...	2.0	3.9	7.6

Data in table III indicate that the nitrification in all the treatments was not alike. The maximum nitrate accumulation with N′ treatment was observed by the fourth week, while with N″ treatment by the second week only. The higher dose of nitrogen gave the highest nitrification. After the period of their maximum accumulation of nitrate, there was a constant decrease in the nitrate content of the soil with the two levels of nitrogen treatments. The loss of nitrogen was proportionately greater with the higher dose of ammonium sulphate. A quite different phenomenon was observed with the phosphate treated soils. There was a regular increase in the nitrate content of the soil treated with super-phosphate even upto the 16th week of the experiment. This may be attributed to the increased nitrogen fixation and nitrification stimulated by phosphate application to the soil, of course there was little difference in the nitrate content with the two levels of phosphorus studied. This also agrees with the observations of Fraps and Sturges (16) who found out that the addition of phosphorus to the soil increased its nitrifying capacity.

There was no trace of nitrate upto the 6th and 10th week with C′ and C″ treatments respectively. From the figures for total nitrogen it can be said that there is no loss of nitrate nitrogen, it is transformed to some other form of nitrogen. This is due to the transformation of nitrate to microbial protein by the increased microbial population of the soil for building up their protoplasm. This falls in line with the observations of Scott (38). Murray (27), Hutchinson and Martin (19) Chapman (9) and Princk, Allison and Gaddy (32) who observed that the addition of filter paper, straw or other carbonaceous materials to the soil resulted in an intense activity of soil micro-organisms and as the demand for nitrogen had been great, so the available nitrogen was utilised by them rather than to appear as nitrate.

The data for total phosphorus in the different treatments are given in table IV and for available phosphorus for the corresponding values are incorporated in table V.

TABLE IV

TOTAL PHOSPHORUS PERCENT IN THE TREATED SOILS.
(ORIGINAL TOTAL PHOSPHORUS—0.0463%)

Treatments—	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week
Control	0,0463	0,0463	0.0465	0,0464	0,0463	0.0463	0,0464	0,0463
N'	0,0463	0,0462	0,0461	0,0463	0,0463	0,0162	0,0464	0,0464
N''	0,0462	0,0462	0.0462	0.0461	0,0462	0.0464	0,0463	0,0463
P'	0.0512	0,0513	0.0514	0,0512	0,0514	0,0513	0,0513	0,0512
P''	0,0563	0,0563	0,0564	0,0563	0,0566	0,0564	0,0563	0,0564
C'	0,0463	0.0462	0,0464	0,0463	0,0463	0,0465	0,0463	0,0464
C''	0.0462	0.0462	0,0463	0,0464	0.0463	0,0462	0,0462	0,0465

TABLE V

AVAILABLE PHOSPHORUS IN MG. PERCENT IN THE TREATED OILS.
(ORIGINAL AVAILABLE PHOSPHORUS—0.93mg%).

Treatments—	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week
Control	0,79	0.88	0.93	0.93	0,87	0.89	0,93	0.93
N'	1.17	1,05	1.27	1,27	1.27	1,29	1.13	1.27
N''	1.21	1,17	1,43	1.43	1.46	1.51	1.32	1.44
P'	1.41	1.39	1,63	1.63	1.63	1.86	1,47	1.53
P''	1.97	1.85	2,43	2.43	2.61	1.97	1,85	1.73
C'	0.19	0.17	0.20	0.20	0.41	0.69	0.76	0.80
C''	—	—	—	—	0.14	0.27	0.47	0.59

From the data in table IV it is observed that there is practically no difference in the amount of total phosphorus throughout the experiments in all the treatments. It is of the order of 0.0463 percent with nitrogen and carbon treated soils and 0.0512 and 0.0563 percent with P' and P'' treatments respectively.

When looked into the data in table V, remarkable differences in the available phosphorus content with the different treatments are observed. From the figures for available phosphorus for control and the two doses of ammonium sulphate treated soils, it is observed that the application of ammonium sulphate had rendered the phosphorus available. This may be attributed to the production of acids, nitric and sulphuric, from ammonium sulphate which render the phosphorus available. Kelley (1918) and Ames (3) also observed that the addition of ammonium sulphate increased the availability of phosphorus. Stalstrom (41) and Haselhoff (17) obtained the greatest amount of solubilization of phosphate with ammonium salts and the least with nitrates, and pointed out that in the case of ammonium salts the organisms remove ammonium as a source of nitrogen leaving the SO_4 in the medium, while in the case of nitrate the acid-ion is removed and the base is left.

It is also observed that the figures for available phosphorus for the higher dose of ammonium sulphate are a bit higher than for the lower dose.

With the two doses of phosphorus application, there had been an increase in the amounts of available phosphorus which, after reaching their maxima, showed a decreasing tendency. A higher value of available phosphorus was recorded with the higher dose of phosphorus application, of course the increase was not proportional to the two levels of phosphorus added.

Available phosphorus content of filter paper treated soil was much lower than the control. There was no trace of available phosphorus with C″ treatment even upto the period of 6 weeks. This may be attributed to the increased microbial activity of the soil and to the microbial fixation of available phosphorus. Troug (45) and Das (11) observed a similar phenomenon and attributed this to the absorption of soluble phosphorus by the organic matter in such a way that citric acid could not extract it. Macdowell (25), Troug (46), Chang (8) and Armi Kaila (4) observed reduction in available phosphorus during the decomposition of carbonaceous material and attributed this to the biological assimilation of soluble phosphorus. Pozerski and Levy (34) also reported the production of soluble phosphates to be associated with the vital function of micro-organisms.

TABLE VI

NUMBERS OF FUNGI IN THOUSANDS PER GM. OF THE TREATED SOILS.

Treatments	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week
Control	17	11	13	12	14	12	12	14
N'	197	157	101	87	46	37	25	19
N''	214	199	112	121	103	65	45	27
P'	96	85	63	59	35	27	19	14
P''	98	89	71	63	32	31	27	21
C'	945	570	380	132	85	48	44	33
C''	960	845	635	345	107	59	47	38

From the data in table VI it is observed that the fungi reached their maximum count by the second week of the experiment in all the treatments. Then there was a constant decrease in their numbers which are highly significant. Vandecaveye and Katznelson (51) also found the maximum numbers of fungi to occur in 20 days. On the other hand Bodily (5) found out that the numbers of fungi did not increase appreciably during the early stages of decomposition. He observed that the rise was gradual to 54 days, after which the increase was more rapid until a maximum was reached in 84 days. The maximum increase in the numbers of fungi was found out in cellulose treated soil followed by nitrogen and phosphorus treated ones. Pathak (31) observed a similar increase in the numbers of soil micro-organisms in soils treated with different manures. Waksman (53) has also pointed out that the addition of carbonaceous material to the soil stimulates largely the development of fungi. Greater increase in the numbers of fungi with the higher doses of nitrogen, phosphorus and carbon was found than with their lower doses, although the increase was not proportional to the two doses of nitrogen, phosphorus and carbon applied.

There was greater increase in the numbers of fungi with the nitrogen treated soils than with phosphorus treated ones. This is because the demand for nitrogen by fungi is more than for phosphorus (the ratio of cell nitrogen to cell phosphorus is 2 : 1). Maze

(26) and Nikolsky (29) found out the nitrogen content of fungi varying between 2.3—6. 6. percent. Schnucke (36) found a definite nitrogen-phosphorus ratio (N : P_2O_5—4.2% : 2.0%) in the mycelium of fungi.

On microscopic examination the species of *Penicilium*, *Aspergillus*, *Trichoderma* and *Fusarium* were noticed in abundance, with *Alternaria* and *Sporotrichum* on few plates.

TABLE VII

NUMBERS OF ACTINOMYCES IN THOUSANDS PER GM. OF THE TREATED SOILS

Treatments	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week
Control	240	247	237	245	285	253	256	235
N'	597	607	565	507	512	486	445	416
N''	635	665	634	604	584	472	452	403
P'	397	400	305	345	312	325	324	315
P''	423	413	387	352	343	323	315	295
C'	885	793	642	623	597	543	454	497
C''	973	843	612	657	606	573	595	507

A perusal of the data in table VII indicates an increase in the numbers of actinomyces in all the treatments. Their maximum numbers with nitrogen and phosphorus treated soils were recorded in the fourth week while with carbon treated soils in the second week. After this a constant decrease in their numbers was noticed in all the treatments. Like fungi, the actinomyces were also recorded the maximum with carbon treated soils followed by nitrogen and phosphorus treated ones. This may be attributed to the utilization of energy from the organic matter and also to a greater demand for nitrogen than for phosphorus by actinomyces. This agrees with the finding of Fousek, who observed that the capacity of decomposing organic matter and using it as a source of energy is well distributed among actinomyces. The numbers of actinomyces recorded were more with the higher doses of nitrogen, phosphorus and carbon than with their lower doses.

TABLE VIII
NUMBERS OF BACTERIA IN MILLIONS PER GM. OF THE TREATED SOILS.

Treatments	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week
Control	4.39	4.53	4.90	5.57	4.39	3.90	4.13	4.40
N'	13.65	14.38	13.96	10.50	10.60	8.75	6.30	6.70
N''	14.36	15.22	15.15	12.62	12.12	10.35	8.50	7.35
P'	9.73	9.81	8.53	7.30	6.35	6.87	7.35	6.70
P''	9.91	9.98	9.12	7.56	8.16	7.60	6.45	7 30
C'	5.93	11.96	17.05	14.70	9.20	9.40	8.58	8.35
C''	7.69	13.17	21.45	17.75	11.16	9.64	9.57	9.07

As is seen from the results in table VIII, there is an increase in the numbers of bacteria in all the treatments. Nitrogen and phosphorus treated soils showed an increase in their bacterial numbers upto the fourth week, but the carbon treated soils behaved otherwise. There was not so much increase in their bacterial numbers upto the 2nd week, but afterwards their numbers increased and reached their maxima in the 6th week. After this a regular significant decrease in their numbers was recorded.

TABLE IX
MILLIGRAMS OF CARBON DIOXIDE EVOLVED PER 100 GMS OF THE TREATED SOILS IN 24 HOURS

Treatments	2nd week	4th week	6th week	8th week	10th week	12th week	14th week	16th week
Control	4.8	5.9	3.7	4.7	6.8	7.1	5.9	6.3
N′	[illegible]	16.7	15.9	14.3	14.4	13.1	11.9	9.7
N′′	14.7	17.1	16.4	15.9	13.7	12.5	11.7	10.1
P′	11.3	12.9	11.7	10.6	9.7	8.7	7.9	7.3
P′′	10.9	13.1	11.9	10.2	9.4	8.9	8.1	7.9
C′	28.9	33.5	36.1	31.9	25.7	21.5	17.9	13.7
C′′	30.1	34.1	36.7	31.1	24.9	22.2	18.3	14.1

It is of interest to note that unlike fungi and actinomyces, in the second week, the highest figures for the bacterial count were recorded with the nitrogen treated soils, but afterwards carbon treated soils gave the maximum bacterial count. A similar phenomenon was observed by Pathak (1953, ii) with different manurial treatments and on a different type of soil. Waksman (1932) has also pointed out that the addition of organic matter stimulates the development of fungi first which is then attacked upon by a large numbers of bacteria. Greater numbers of bacteria were recorded with the higher dose of nitrogen, phosphorus and carbon added to the soil.

As revealed from the data in table IX, there was a rapid increase in the amount of carbon dioxide evolved by the different treatments. A rapid increase in carbon dioxide evolution with ammonium sulphate and phosphate treated soils was found upto the fourth week, while upto the sixth week with carbon treated soil. There was not much difference in the amounts of carbon dioxide evolved with the two levels of nitrogen, phosphorus and carbon treated soils. A greater amount of carbon dioxide evolution throughout with carbon treated soils than with nitrogen and phosphorus treated ones was observed. This is obviously due to the greater microbial activity of the carbon treated soils. On the second week, when there was not much increase in the numbers of bacteria, the greater amount of carbon dioxide evolution with carbon treated soils than with nitrogen and phosphorus treated ones may be attributed to the vigorous activities of fungi and actinomyces. This agrees with the findings of Neller (28) and Potter and Synder (33) who observed that when organic matter is added to the soil, fungi grow very rapidly and produce a great amount of carbon dioxide than do bacteria. After reaching their maxima a regular decrease in the amount of carbon dioxide evolution was noticed with all the treatments.

A comparison of the data in tables VI VII and VIII with the data in table IX shows a correlation with the numbers of micro-organisms and carbon dioxide evolution of the treated soils. A similar result was obtained by Van Suchtelen (52), Russell and Appleyard (35), Stoklasa (42) and Bodily (5).

DISCUSSION

The changes nitrogen, phosphorus and carbon undergo in soil are the result of the activities of the soil micro-organisms.

Incorporation of ammonium sulphate, super phosphate and filter paper stimulated microbial activities in the soil, which resulted in the evolution of carbon dioxide with the loss of organic carbon from the soil. Also there was a tendency towards the loss of soil nitrogen with ammonium sulphate treated soils, which was greater with its higher dose. The narrower the C/N ratio the greater is the possibility of nitrogen to be lost, while with wider C/N ratio as with the application of carbon to the soil, appreciable fixation of nitrogen from the atmosphere occurred. Acharya, Sabnis and Menezest (1) also observed a similar phenomenon. An appreciable fixation of atmospheric nitrogen to the soil occurred with the phosphorus treated soils. Since the ratio of cell nitrogen to cell phosphorus is constant (2 : 1), this seems quite reasonable that the incorporation of phosphorus to the soil stimulated the activity of Azotobacter which fixed nitrogen from the atmosphere.

Looking to the figures for nitrate, it is observed that ammonium sulphate treated soils gave the highest nitrification followed by phosphate treated ones. The increased nitrification by phosphate treated soils may be due firstly, to the neutralization of acids produced during nitrification by the calcium of super phosphate and thus creating a favourable reaction for bacterial activity and secondly, to the increased activity of bacteria stimulated by phosphate itself. On the other hand there was no trace of nitrate with the carbon treated soils in the beginning. This is because the changes affecting carbon and proteinous nitrogen and available nitrogen are intimately associated. Nitrogen can appear as nitrate only when it exceeds a certain critical amount relative to carbon. Generally if C/N ratio is near about 12, the excess goes off as carbon dioxide and nitrogen remains as protein, any available nitrogen present is also converted into protein. On the other hand when the proportion of nitrogen becomes greater, the excess is changed into nitrate which may be taken up by plants or otherwise lost from the soil. A similar phenomenon was observed with the available phosphorus of filter paper treated soils . This is because the production of soluble phosphates is associated with the vital functions of micro-organisms. It is of interest to note that there is an increase in the amount of avilable phosphates with ammonium sulphate treated soils. The acids, produced by the application of ammonium sulphate, increase the availability of phosphorus. Hopkin and Whitings (18) Kelley (20) and Ames (3) obtained a similar result.

The application of nitrogen, phosphorus and carbon to the soil stimulated the growth and activity of fungi, actinomyces, and bacteria which brought about a series of changes in the nutrients. Since fungi require more nitrogen than do bacteria because the former produce more cellular material, the absence of nitrates with the filter paper treated soils in the beginning is associated with the development of fungi and actinomyces. There appears no positive correlation with the nitrifying capacity of the treated soil and their microbial numbers or the carbon dioxide evolution. Maximum nitrate accumulation was found out with ammonium sulphate treated soils while the highest microbial numbers recorded were with filter paper treated soil which is somewhat correlated with carbon dioxide evolution of the soil. Pathak (31) observed a similar phenomenon with the soil treated with different manures. Lohnis (24) also found out a similar phenomenon. On the other hand Stoklasa (42) and Norman (30) observed a direct relationship between nitrifying capacity, bacterial numbers and carbon dioxide evolution of the soil.

SUMMARY

An attempt was made to study the activity of micro-organisms affecting nitrogen, phosphorus and carbon changes in soil. It was noticed that there was a regular loss of carbon with all the treatments which was highest with filter paper treated soils. A gain of total nitrogen was observed with phosphorus and carbon treated soils while a loss of total nitrogen was observed with ammonium sulphate treated one. Phosphate stimulated nitrification while, in the beginning, there was nitrate depression with carbon treated soils. Ammonium sulphate increased the availability of phosphorus, whereas the available phosphorus of carbon treated soil was greatly reduced. Maximum available phosphorus was found with the soils treated with super-phosphate. There was enormous increase in the numbers of fungi, actinomyces and bacteria and also in the evolution of carbon dioxide in all the treatments. There appears some correlation with the numbers of microorganisms and carbon dioxide evolution of the soil, but no relationship was observed with nitrifying capacity of the soil and microbial numbers or carbon dioxide evolution of the soil.

REFERENCES

1. Acharya, C. N., Sabnis, C. V. and F. G. T. Menezest 1946. *J. agric. Sci.* **16** :178.
2. Allen, O. N., Abel, F. A. E. and O. C. Magistad, 1934. *Trop. Agri.* (Trinidad) **11** : 285.
3. Ames, J. W. 1921. *Ohio agric. exptl. Sta. Bulb.* 351.
4. Armi Kaila 1949. *Soil Sci.* **68** : 277.

5. Bodily, H. L. 1944. *Soil Sci.*, **57** : 341.
6. Bonazzi, A. 1921. *J. Bact.*, **6** : 331.
7. Broadbent F. E. and W. V. Bartholomew, 1948. *Proc. Soil Sci. Soc. Amer.*, **13** : 271.
8. Chang S. C. 1939. *Soil Sci.*, **48** : 35.
9. Chapman, H. D. 1936. *J. Amer. Soc. Agron.*, 28 : 35.
10. Corbet, A. S. 1934. *Soil., Sci.*, **37** : 109.
11. Das, S. 1945. *Indian J. agric. Sci.*, **15** : 42.
12. Demolon, A. and G. Barbier, 1930. *Ann. Sci. Agron. France*, **47** : 329.
13. Dushechkin, A. J. 1911. *Abs. exptl. Sta. Rec.* **27** : 216 (1912).
14. Dvorak, J. and H. B. Hutchinson. 1918. *J. agric. Sci.*, 8.
15. Dzierzbicki, A. 1910. *Bull. Intern. Acad. Sci. Cracovie.* B-21-66.
16. Fraps, G. S. and A. J. Sterges 1939. *Soil Sci.*, **47** : 115.
17. Haselhoff, E. 1909. *Landw Vers. Sta.* **70** : 53.
18. Hopkin, C. G. and A. L. Whiting. 1916. *Ill. Agr. Exp. Sta. Bull.* 190.
19. Hutchinson, I. J. and T. L. Martin 1934. *J. Amer. Soc. Agron*, **26** : 333.
20. Kelley. W. P. 1918. *J. agric. Sci.*, **12** : 682.
21. Krishna, P. G. 1928. *J. Amer. Soc. Agron.*, 20.
22. Lipman, J. G. 1930. *J. Bact.* **19** : 389.
23. Lockett, J. L. 1938. *Soil Sci.*, **45** : 13.
24. Lohnis. F. 1926. *Landw. Jehrb.*, **42** : 751.
25. Macdowell, N. S. 1908. *Wis. Exp. Sta. Res. Bull.* 19.
26. Maze, P. 1902. *Ann. Inst. Past.*, **16** :346.
27. Murray, T. J. 1921. *Soil Sci.*, **12** : 233.
28. Neller, J. R. 1918 *Soil. Sci.*, **5** : 225.
29. Nikolsky, M. 1904. *Centrbl. Bakt.*, (2) **12** : 554-559, 656-675.
30. Norman, A. G. 1930. *Ann. appl. Biol.*, **17** : 575.
31. Pathak, A. N. 1953. *J. Soil and Water Cons. India*, **2** : 29-34.
32. Plinck, L. A., Allison, F. E. and V. L. Gaddy, 1946. *J. Amer. Soc. Agron*, **38** : 410.
33. Potter, R. S. and R. S. Snyder, 1918. *Soil. Sci.*, **5** : 359.
34. Pozerski, E. and M. M. Levy, 1922. *Compt. Rend. Soc. Biol.* **87** : 1157.
35. Russell, E. J. and A. Appleyard 1915. *J. agric. Sci.*, **7** : 1.
36. Schnucke, R. 1928. *Centrbl. Bakt.* (2) **75** : 237.
37. Schreiner, O. 1923. *J. Amer. Soc. Agron.*, **15**, 117.
38. Scott. H. 1921. *J. Amer. Soc. Agron.* **13** : 233.
39. Smith, F. B. and P. E. Brown, 1932. *Iowa agri. Exp. Sta. Res. Bull.* 147.
40. Smith, N. R. and H. Humfeld, 1930-31. *J. agric. Res.*, **41** : 97-123; **43** : 715-731.
41. Stalstrom, A. 1904. *Centrbl. Bakt.* (2) **11** : 724.
42. Stoklasa, J. 1911. *Centbl. Bakt.* (2) **29** : 385.
43. Staklasa, J. 1922. *Chem. Ztg.*, **46** : 681.
44. Tam, R. K. and O. C. Magistad, 1936. *Soil. Sci.*, **41** : 315.
45. Troug E. 1907. *U. S. Dept. Agric. Bur. Soil. Bull.*, **41** 33.
46. Troug, E. 1912. *Wis. exp. Sta. Res. Bull.* 29.
47. Troug E. 1930. *J. Amer. Soc. Agron.*, **22** : 874.
48. Vandecaveye, S. C. and M. C. Allen, 1935. *Soil. Sci.*, **40** : 331.
49. Vandecaveye, S. C. and G. D. Baker. 1938. *Soil. Sci.*, **45** : 315.
50. Vandecaveye, S. C. and H. Katznelson. 1938. *Soil Sci.*, **46** : 139.
51. Vandecaveye, S. C. and B. R. Villanueva, 1934. *Soil Sci.*, **38** : 191.
52. Van Suchtelen F. H. 1910. *Centrbl. Bakt.* (2) **28** : 45.
53. Waksman, S. A. 1932. Principles of soil microbiology : 2nd Ed. Baltimore. The William and Walkins Co.
54. Whiting, A. L. and Heck, A. F. 1926. *Soil. Sci.*, **22** : 477.
55. Winogradsky, S. and J. Ziemiecka. 1928. *Ann. Inst. Pasteur*, **42** : 36
56. Ziemiecka, J. 1932. *J. agric. Sci.*, **22** : 797.

FLUORESCENCE AND JOSHI EFFECT

By A. P. Saxena, *Reader in Physics, Holkar College, Indore;* and M. V. Ramanamurti, *Assistant Professor of Chemistry, Hindu University, Banaras.*

Robinwitch and Wood and others (1, 2, 3) have observed a marked quenching of the Fluorescence of excited iodine vapour when diluted by other foreign gases. Iodine vapour subjected to silent electric discharge shows an appreciable Joshi Effect (±Δi), viz. an instantaneous and reversible photo-variation of the discharge current, *i* flowing through the vapour by but visible light (14, 15, 16, 17). The object of the present investigation was to study the effect on both ±Δi, of admixture of the iodine vapour with different pressures of dry air, and to establish some relation between the quenching of fluorescence and the inhibition of Joshi Effect.

Experimental

The general assemblage of the apparatus and the electrical circuit employed are shown in Fig. 1. Siemens' type (all glass) fullozonizers and Pt-wire-in-(glass) cylinder type semi-ozonizers

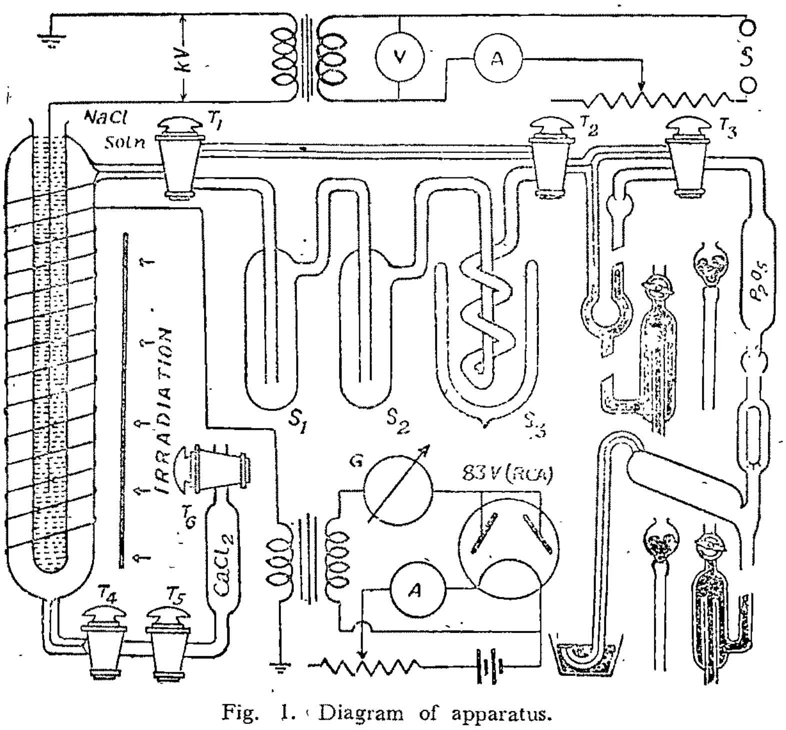


Fig. 1. Diagram of apparatus.

were employed. They were filled with iodine vapour at 0·3 mm (Hg) pressure and were excited by 50 cycle potentials obtained from a rotary convertor worked off 220 volt D. C. mains and stepped up by a high tension transformer. The discharge current was measured by means of a sensitive moving coil galvanometer actuated by an inductively coupled diode 83V (RCA). The diode was used as a half wave rectifier. The current when the ozonizer was screened from light (from a 200 watt 220 volt incandescent glass bulb) i_D and when exposed to it i_L was observed. The difference i_D-i_L=Δi measured the net *Joshi Effect* and its relative value *viz.* % Δi=100 X $\Delta i/i_D$ served for comparison.

The data given in Tables 1 and 2 refer to a Siemens' ozonizer (A) and a semi-ozonizer (B) having the following dimensions.

Siemens' ozonizer (A)	
External diameter of outer tube	20 mm
External diameter of inner tube	15 mm
Thickness of glass " " "	1 mm
Inter electrode distance	4 mm
Length of discharge column	285 cm.

Semi-ozonizer (B)	
Length of the tube	300 mm
Outer diameter	10 mm
Diameter of Pt. wire	0.4 mm

The tubes (A) and (B) were initially filled with *pure* sample of iodine vapour (0·3 mm Hg). Traps S_1 and S_2 containing gold foil and a cooling spiral S_3 (Cf. Fig. 1) served to eliminate the last traces of mercury. Joshi effect was studied at various potentials V altered in the range 0-2 kV. Air freed from moisture by passing through a train of drying tubes containing anhydrous calcium chloride, was then introduced into the ozonizer in small quantities at a time. The total pressure of the mixture in the ozonizer (altered in the range 5-150 mm Hg) was read directly on the mercury manometer M (Cf. Fig. 1). At each pressure the tubes were excited and $\pm\Delta i$ was studied. The data obtained are shown in Tables 1 and 2 and in part in Figs. 2-3.

RESULTS

The foregoing data reveal that admixture even in traces of an impurity e. g., dry air is highly detrimental to the negative Joshi Effect ($-\Delta i$) in iodine vapour. Thus e. g.,$-\%\Delta i$ decreased numerically from 48 to 19 on addition of nearly 8 mm air and was reduced to zero at 19 mm of the mixture (air + iodine).

The positive Joshi Effect ($+\triangle i$) observed at low volgtages ($<V_m$, the threshold potential) however, was unaffected by the presence of the added impurity. Appreciable $+\triangle i$ persisted even at large pressures of the gas mixture *e. g.*, upto 150 mm (cf. Figs. 2-3).

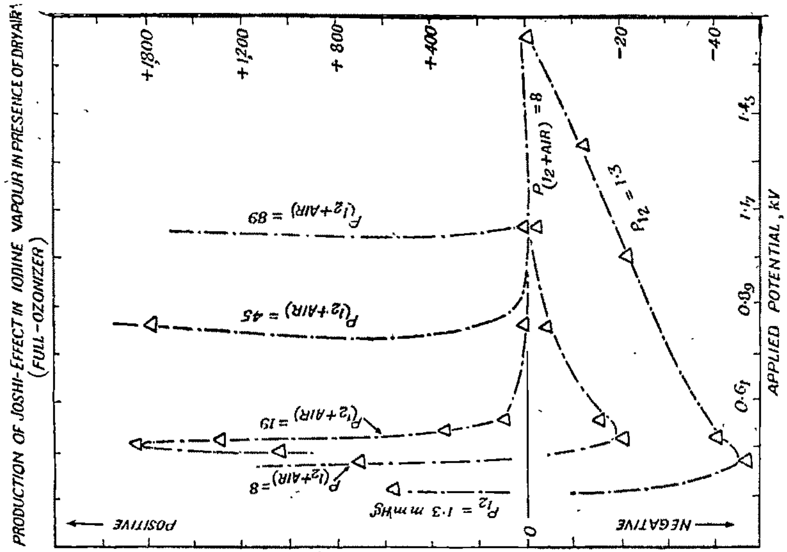


Fig. 2

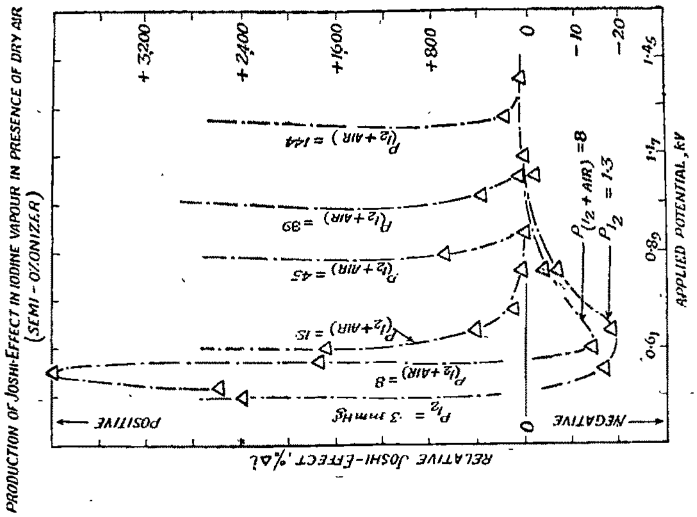


Fig. 3

The inhibitive influence on Joshi Effect ($-\triangle i$) of admixture of air with iodine vapour is comparable to its quenching action on the fluorescence of iodine vapour. A detailed review of the photoprocesses in iodine vapour especially of the fluorescence phenomenon was made by Noyes and Leighton (1) in their "Photochemistry of Gases". The fluorescence of iodine was extensively investigated by Noyes (2), Rabinowitch and Wood (3). The quenching of fluorescence, according to the above authors is due to an increased number of molecular collisions as a result of increased pressure either of its own or by the addition of a foreign gas *e.g.*, air, carbon dioxide nitrogen, argon etc. It is attributed to the dissociation of excited iodine molecules. Noyes (2) showed that the dissociation is caused due to a perturbation between two upper levels which is enhanced by an external magnetic field. Rabinowitch and Wood (3) have shown that all excited iodine molecules dissociate by collision with foreign molecules (X), and that quenching of fluorescence of iodine by a foreign molecule is not due to a dissipation process *e. g.* $I_2^* + X \rightarrow I + X$, but entirely to the dissociation of I_2^* as $I_2^* + X \rightarrow I + I + X$ Rabinowitch and Wood (3) observed that the intensity of iodine fluorescence is reduced to half of its original value by a few mm (Hg) of nitrogen or argon. Turner and Vanvlec (4) explained quenching of fluorescence by magnetic fields to be due to a catalytic dissociation of iodine molecules (I_2^*); the catalyst (in place of X) being the applied magnetic field. Wood and Spears (5) have shown that the intensity of fluorescence spectrum of iodine is reduced from 100—19 by 11 mm air and 7 mm CO_2. Frank (6) observed that the line spectrum of iodine vapour when subjected to the action of a monochromatic light is transformed into the banded spectrum in presence of small traces of foreign gases.

Despite the marked similarity (*vide supra*) in the inhibitive influence of dilution of the I_2 vapour with a foreign gas, on Joshi Effect on one and on the fluorescence phenomenon on the other in iodine vapour, the following considerations of Joshi effect ($-\triangle i$) established by Joshi indicate that $\triangle i$ is not related to the fluorescence phenomenon. Joshi 7-9 has shown that the effect ($-\triangle i$) is essentially of electrode surface origin and occurs in almost all gases when they are excited by electrical fields and irradiated by (light) wavelengths within and *even* outside the selective absorption of the vapour. It was also shown by him (10) that the onset of dielectric breakdown of the vapour under applied fields is an essential prerequisite for the occurrence of the Joshi effect.

It may be recalled however, that Joshi's theory (9-11) for the phenomenon ($\triangle i$) contemplates formation of wall-adsorbed layers of excited gas molecules derived from the gas phase, as fundamental for the occurrence of $\triangle i$. It was further suggested (12) that (i) these molecules in the 'layers' orient themselves into series of dipoles extending from the electrode surface into the gas bulk; (ii) the dipoles are ionised under applied fields (corresponding to $V > V_m$) yielding electrons which initiate the current (i) and (iii) photodissociation of these dipoles into neutral atoms leads to a reduced i (*i.e.* to $-\triangle i$). A predissociation of the dipoles into atoms by the added foreign gas molecules (as in quenching of fluorescence *vide supra*) therefore, might be responsible for their inhibitive influence on Joshi effect.

SUMMARY

Addition of a foreign gas *e. g.,* air to iodine vapour subjected to silent electric discharge inhibited the occurrence of negative *Joshi effect* ($-\triangle i$). This is comparable to a like influence of the above factor on the fluorescence of iodine vapour which indicates an apparent relationship of *Joshi effect* and the fluorescence of iodine. Joshi's findings of $\triangle i$ *viz.,* its essentially electrode-surface origin, its occurrence even with (light) wavelengths outside the selective absorption of the gaseous medium and its occurrence only at $V > Vm$, the threshold potential, reveal that $-\triangle$ is independent of the above phenomenon viz., fluorescence in iodine vapour.

Positive *Joshi effect* (% $\triangle$i) observed at $V < Vm$ however, remained unaffected by the admixture of I_2 with a foreign gas.

Authors' grateful thanks are due to Prof. S. S. Joshi, D. Sc. (Lond.) F. R. I. C. (Lond.) F. A. Sc., F. N. I. for suggesting the problem and to Dr. W. V. Bhagwat for his kind interest during the progress of the work.

REFERENCES

1. NOYES W. A., and LEIGHTON P. A. 1941. "The Photochemistry of gases", Reinhold Publishing Corporation, N. Y.
2. NOYES, W. A. 1923. *J. American chem. Soc.,* **45** : 337.
3. RABINOWITCH and WOOD, 1936. *Trans. Farad. Soc.,* **32** : 547 *J. chem. Phys.,* **4** : 358.
4. TURNER and VANVLEC, see Rabinowitch and Wood. 1936. *J. chem. Phys.,* **4** : 358.
5. WOOD and SPEARS, 1914, *Phil. Mag.* (vi) **27** : 531.
6. FRANK, 1912, *Ber. Deut. Phys. Ges.,* **14** : 419
7. JOSHI, S. S. 1945, 1939. *Curr. Sci.,* **8**: 548; *ibid.,* **14** : 67
8. JOSHI, S. S. 1944. *Nature* 154, 147: *Proc. Indian Acad. Sci.,* A. **22** : 339 (1945).
9. JOSHI, S. S., Presid. Address, *Indian Sci. Cong. Chem. Sec.,* (1943).
10. JOSHI, S. S. 1946. *Curr. Sci.* **15** : 281; **16** : 19 (1947).

Table 1: Production of *Joshi Effect* in Iodine Vapour in Presence of Air under Full-Ozoniser Excitation.

(a) Partial pressure of I^2 =0.3mm Hg.
Pressure of (air +I^2) =0.3mm Hg.

kV	iD	iL	Δi	%Δi
0.33	...	0.5	+0.5	+
0.36	0.5	3.4	+2.9	+580
0.37	3.8	4.6	+0.8	+25
0.38	5·2	5.2	...	...
0.39	3.6	3.6	...	...
0.44	5.5	2.5	-3.0	-46
0.56	7.5	4.5	-3.0	-40
1.11	12.8	10.2	-2.6	-21
1.39	20.0	17.5	-2.5	-12.5
1.67	49.0	49.0	...	...

(b) Partial pressure of I^2 =0.3mm Hg.
Pressure of (air+I^2) =8 mm Hg.

kV	iD	iL	Δi	%Δi
0.36	...	...	...	...
0.87	...	0.6	+0.6	+
0.38	...	6.2	+6.2	+
0 39	...	2 5	+2 5	+
0.44	12.5	12.5	...	...
0.50	18.0	14.4	—3.6	—20
0.56	18.4	15.5	-2.9	—15.8
0.83	22.9	22.0	-0.9	—3.9
1.11	26.3	25.7	-0.6	—2.3
1.39	32.6	32.6	...	...
1.67	54.6	54.6	...	...

(c) Partial pressure of I^2 =0.3mm Hg.
Pressure of (air—I^2) =19mm Hg.

kV	iD	iL	Δi	%Δi
0.44	...	...	...	...
0.47	0.3	3.5	+3.2	+1070
0.49	0.5	8.8	+8.3	+660
0.50	0.8	11.5	+10.7	+1310
0.52	3.0	13.8	+10.8	+360
0.56	7.0	14.6	+7.6	+110
0.67	15.5	15.0	—0.5	—3
0.83	19.9	19.6	—0.3	—1.5
1.11	31.8	31.8	...	...
1.39	40.6	40.6	...	...
1.67	65.8	65.8	...	...

(d) Partial pressure of I^2 =0.3mm Hg.
Pressure of (air +I_2)=45 mm Hg.

kV	iD	iL	iΔ	%Δi
0.67	...	...	...	...
0.78	...	2.5	+2.5	+
0.83	0.8	13.5	+12.7	+1600
0.89	27.5	27.5	...	...
1.00	29.5	29.5	...	...
1.11	31.4	31.4	...	...
1.39	46.8	46.8	...	...
1.67	85.5	85.5	...	...

(e) partial pressure of I^2 =0.3mm Hg.
pressure of (air+I^2) =8×9mm Hg.

kV	iD	iL	Δi	%Δi
0.89	...	...	...	...
1.00	...	...	...	...
1.05		2.5	+2.5	+∞
1.11	48.4	48.4	...	...
1.22	58.5	58.5	...	...
1.39	98.0	98.0	...	...

(f) Partial pressure of I^2 =0.3mm Hg.
Pressure of (air+I^2) =144mm Hg.

kV	iD	iL	Δi	%Δi
1.11	...	...	...	...
1.22	0.3	0.3	...	...
1.37	0.0	0.0	...	...
1.39	21.5	21.5	...	...
1.55	109.5	199.5	...	...

(g) Partial pressure of I^2 =0.3mm Hg.
Pressure of (air+I^2) =200mm Hg.

kV	iD	iL	Δi	%Δi
1.37	...	...	...	...
1.39	2.5	2.5	...	...
1.55	14.0	14.0	...	...
1.67	56.0	56.0	...	...
1.83	117.0	117.0	...	...

Table 2: Production of *Joshi Effect* in Iodine Vapour in Presence of Air under Semi-Ozoniser Excitation.

(a) Partial pressure of I^2 = 0.3mm Hg.
Pressure of (air+I^2) = 0.3mm Hg.

kV	iD	iL	Δi	%Δi
0.39	...	0.4	+0.4	+
0.44	...	11.4	+11.4	+
0.50	...	16.4	+16.4	+
0.56	21.9	18.4	—3.5	—16.0
0.66	21.9	18.0	—3.9	—17.7
0.83	24.9	23.4	—1.5	—6.0
1.11	28.9	28.9	...	...
1.39	43.9	43.9	...	...

(b) Partial pressure of I^2=0.3 mm Hg.
Pressure of (air +I^2)= 8 mm Hg.

kV	iD	iL	Δi	%Δi
0.39	...	...	...	...
0.44	0.1	2.7	+2.6	+2600
0.50	0.2	5.3	+5.1	+2550
0.56	0.3	12.1	+11.8	+3900
0.61	21.4	24.4	—3.0	—14.0
0.66	28.9	28.9	...	...
0 83	39.9	38.4	—1.5	—3.7
1.11	44.4	43.4	—1 0	—2.2
1.39	38.4	38.4	...	...

(c) Partial pressure of I^2=0.3 mm Hg.
Pressure of (air+I_2)=19 mm Hg.

kV	iD	iL	Δi	%Δi
0.50	...	...	...	...
0.55	...	...	...	...
0,61	0.5	11.0	+10.5	+2100
0 66	5.2	28.5	+23.3	+450
0.72	21.5	36.0	+14.5	+67
0.83	57.5	57.5	...	...
1.11	97.0	97.0	...	...
1.39	100.5	100.5	...	...

(d) Partial pressure of I^2=0.3 mm Hg.
Pressure of (air+I^2)=45 mm Hg,

kV	iD	iL	Δi	%Δi
0.77	...	0 5	+0.5	+
0.86		4.0	+3.5	+
0.89	0.5	4.0	+3.5	+700
0.93	70.5	70.5	...	...
1.00	84.0	84.0	...	...
1.11	98.4	98.4	...	...
1.39	169.5	169.5	...	...

(e) Partial pressure of I^2=0.3 mm Hg.
Pressure of (air+I^2)=89 mm Hg.

kV	iD	iL	Δi	%Δi
0 89	...	0.5	+0.5	+
0.95	...	2.3	+2.3	+
1.00	...	6.0	+6.0	+
1.05	0.4	16.3	+15.9	+370
1.11	69.5	89.5	+20.0	+30
1.22	174.5	174.5	...	...

(f) Partial pressure of I^2=0.3 mm Hg.
Pressure of (air=I^2)=144 mm Hg.

kV	iD	iL	Δi	%Δi
1.00	...	...	...	...
1.05	...	1.5	+1.5	+
1.11	...	2.0	+2.0	+
1.17	...	4.5	+4.5	+
1.28	8.0	19.5	+11.8	+150
1.39	154.5	154.5	...	...

(g) Partial pressure of I^2=0.3 mm Hg.
Pressure of (air +I^2)=200 mm Hg.

kV	iD	iL	Δi	%Δi
1.11	...	...	...	...
1.16	0.5	0.5	...	...
1.22	1.0	1.0	...	...
1.27	1.5	1.5	...	...
1.33	6.0	6.0	...	...
1.38	15.5	15.5	...	...
1.49	44.5	44.5	...	...
1.54	174.5	174.5	...	...

EFFECT OF SODIUM DICHLORO-PHENOXYACETAE ON CROP AND WEEDS IN WHEAT FIELD

By H. K. PANDE, *Department of Agronomy*, *B. R. College*, *Agra.*

In previous paper (18) the author described experiment conducted in 1951-52 on weed control in wheat field. This experiment showed the effect of sod. dichloro-phenoxyacetate (Fernoxone) on yield of wheat. Nearly all the weeds (except *Cyperus rotundus*), in the sprayed plots, under the three concentrations (3.25, 4.88 and 6.50 pound rates), were killed or severely checked at all the three stages (6, 9, and 12 weeks after sowing). Only the data for grain yield were discussed. The lower concentrations applied at earlier stages showed promising results. This showed the need for further study to have precise information. During next 'rabi' season (1952-53) an experiment on the same line was conducted again at B. R. College, Research Farm, Bichpuri, Agra. In the present paper the author discusses the effect of the treatments applied at three stages on development, yield and quality of grain in wheat and on the mortality of weeds.

EXPERIMENTAL METHODS

The methods are presented in detail in the previous paper (18). In the present experiment the plot size varied. The individual plots measured 6 × 6 instead of 4 × 4 of the previous year (1951-52). The experiment was laid down on normal farm crop of wheat with a natural weed population, taking, however, care to select a field with as uniform stands of weeds as possible. The treatments of spray concentrations with 3.25, 4.88 and 6.50 pound rates of sod. dichlorophenoxyacetate, hand-weeded check and check receiving no treatments, were applied at three stages of crop growth and each replicated four times making in all 60 plots. The herbicide was applied as aqueous solution by means of knapsack sprayer at the standard volume of 100 gal. /acre. Hand-weeding was done using 'khurpi' i. e. hand-hoe. All weeding treatments were given on the same day. The degree of kill obtained was estimated by counting the number of living plants of each weed species on each plot in randomly selected quadrates of 1 sq. ft. The density of weeds in each plot was estimated prior to spraying and again three weeks later. The figures were adjusted for any natural change in population during the period between two counts. Apart from determining the degree of weed control the plots were harvested to determine any change in the level of grain produced. At maturity of the crop, 5 plants from each plot were taken out for studying their characters, the crops on the individual plot were harvested separately and weighed for total dry matter. All the fertile shoots per plot were counted, threshed and winnowed and grain was weighed. The data for development and yield were statistically analysed following the methods of analysis of variance due to Yates (25). Taking counts of weeds before and after spraying, the results were expressed as percentage kill based on the percentage change of density in each plot. To test the quality of grain, samples of wheat grain from each treatment were chemically analysed for total nitrogen following the Gunning Kjedahl method (A. O. A. C., p. 28, 6th Ed., 1945) and data were represented as mean nitrogen contents of grain.

EXPERIMENTAL RESULTS

The results set out in Table I, provide information on relative effects of the three cocentrations of Fernoxone on 7 annual and 2 perennial weeds of wheat field. Count of the weed population indicated that there was a fairly uniform stand of weeds in all the plots. The weeds enumerated in Table I were competing with crop plants. The crop was highly infested with weeds as only 9.5 per cent of the total population comprised wheat plants, while weeds like *Asphodelus tenuifolius* and *Chenopodium album* constituted 31.6 and 28.9 per cent. of the total population respectively.

The study of the Table I indicates that at earlier stages of weed growth, even the lowest spray concentrations brought more than 80 per cent. kill of all the weeds except *Cyperus rotundus*. *Spergula arvensis*, no doubt, proved little resistant at 3.25 pound rate, but like other weeds increased rate of concentrations brought more or less complete kill of this weed also. With advanced stage of development all the weeds showed slight resistance to the toxic effect of the herbicide. This was more pronounced in case of *A. tenuifolius* and *C. album*.

TABLE I

Inter-relationship between stage of development and the susceptibility of weeds in wheat field; to spray concentration of sod. dichloro-phenoxyacetate.

Crop and chief weeds present	Density on untreated plot		Percentage kill Stage of development								
			Tiller spray lb./acre			Boot Spray lb./acre			Bloom Spray lb./acre		
	Plant per sq. ft.	% of total population	3.25	4.88	6.50	3.25	4.88	6.50	3.25	4.88	6.50
Wheat	5.6	9.5	—	—	—	—	—	—	—	—	—
Asphodelus tenuifolius	20.5	34.2	89	89	98	79	86	90	78	82	86
Chenopodium album	18.7	31.5	87	96	93	73	83	86	74	84	82
Melilotus sp.	7.4	12.5	90	97	100	84	88	95	82	90	90
Vicia sp.	1.9	3.3	89	89	100	80	89	100	82	90	99
Spergula arvensis	1.7	2.9	62	89	100	59	82	93	68	77	97
Fumaria parviflora	1.5	2.6	80	87	100	76	93	90	71	84	92
Convolvulus arvensis	0.5	0.8	86	91	100	79	94	88	83	90	92
Cyperus rotundus	1.6	2.7	8	13	13	7	10	11	7	10	9

The appearance of the affected plants was extremely interesting. Within two days, the leaves began to curl and bend and the stem to twist in a typical epinastic response (Plate I). In case of *A. tenuifolious* and *C. album*, the leaves turned yellow and then red. The stem became very swollen with splits in the epidermis. In *C. album* the excresences, which seemed to consist of a coalescing mass of numerous root-initials that failed to develop (Plate II). The leaves and finally the stems then completely died away.

TABLE II.

The comparative effect of the three spray concentrations of sodium dichloro-phenoxy-acetate on growth and yield of wheat.

Treatment	Length of ear cm.	Total No. of spike-lets per ear	No. of fertile spike-lets per ear	No. of grain per ear	No. of fertile shoots per plot [6' x 6']	Total dry matter per plot [6' x 6'] gm.	Grain yield per plot [6' x 6'] gm.
Sod. dichloro—phenoxyacetate 3.25 lb/acre	7.8	17.1	15.0	30.4	368.8	1355.8	428.5
4.88 ,,	7.9	17.0	14.5	28.0	374.2	1362.9	421.1
6.50 ,,	7.6	17.0	14.5	28.3	376.0	1365.8	414.0
Weeded check	8.0	18.1	16.2	34.5	384.6	1423.1	491.8
Unweeded ,,	7.3	17.1	14.8	29.4	332.0	1155.8	366.5
Critical diff. a 5%	N. S.	N. S.	0.64	2.99	29.00	172.67	66.28
a 1%			0.85	3.94	38.18	227.29	87.25

The expected increase in yield as a result of weed control may also depend upon the time and the methods of application. The comparative effects of the weed control due to the three spray concentrations and their comparisons with weeded and unweeded checks are evident from Table II. The plots sprayed with 3.25 pound rate gave higher yields of grain than did those sprayed with

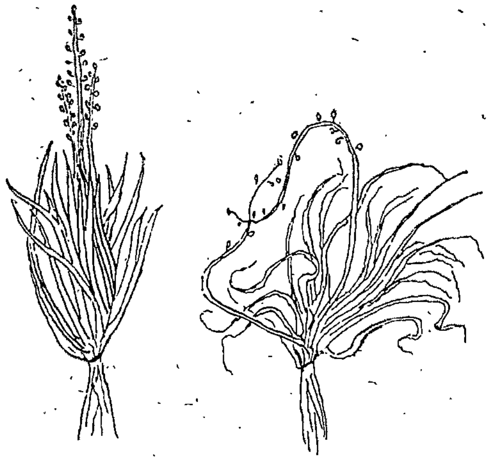


Fig. 1. On left a normal plant and on right affected *Asphodelus tenuifolius* the latter shows the bending and twisting of leaves following sod. 2, 4. D-spray.

4.88 and 6.50 pound rates. However, the differences were not significant. The plots treated with 4.88 and 6.50 pound rates gave significantly (5 per cent) lower yields than did the weeded check, while the yields of hand-weeded plot and that of sprayed with 3.25 pound rate did not vary significantly. The decrease in yield was also accompanied with significant decrease (1 per cent) in fertile spikelets and grain number per ear. However, there was no significant difference for fertile shoots and dry matter per plot. The treated plots showed marked increase (5 per cent) in fertile shoots and dry matter over unweeded check but there was no significant difference for fertile spikelets and grain number per ear and grain yield per plot. Superiority of weeded check over unweeded one was marked with significant increase (1 per cent) in fertile spikelets and grain number per ear, and fertile shoots, dry matter and grain yield per plot.

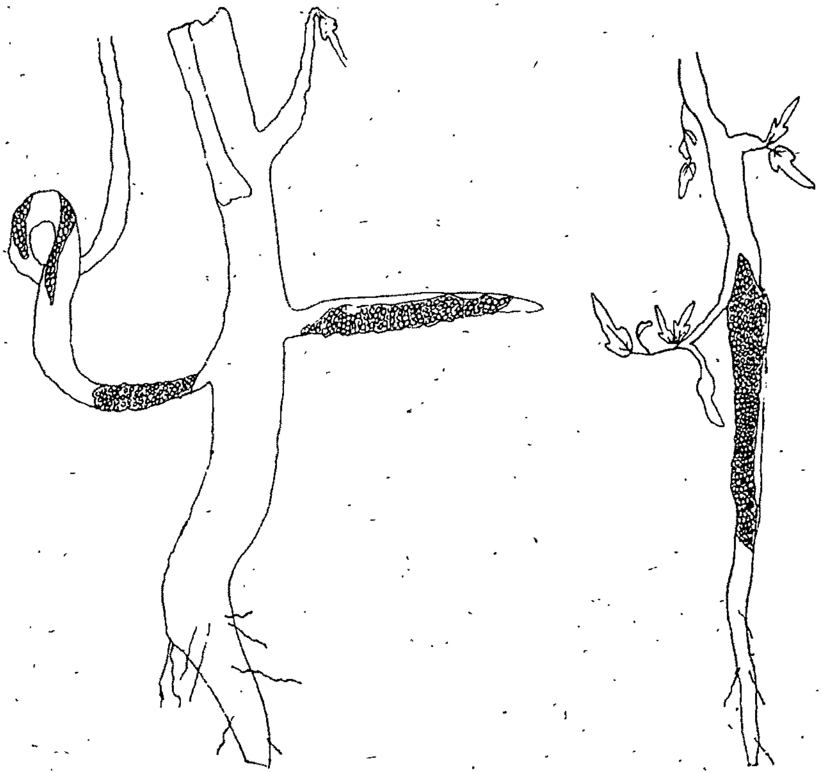


Fig. 2. On left swollen stem with cracks and on right excrescences on lower part of stem of *Chenopodium album* following sod. 2, 4-Dspray.

TABLE III.

The effect of stage of development on the relative response of wheat to spray treatments of Sod. dichloro-phenoxyacetate.

Stage of growth	Length of ear cm.	Total No. of spikelets per ear	No. of fertile spikelets per ear	No. of grain per ear	No. of fertile shoots per plot (6'x 6')	Wt. of dry matter per plot (6' x 6') gm.	Grain yield per plot (6' x 6') gm.
Tiller	7.9	17.6	15.7	32.4	378.1	1362.8	482.2
Boot	7.7	17.1	14.7	29.3	360.5	1317.6	398.6
Bloom	7.5	17.1	14.6	28.7	362.8	1317.6	392.4
Critical diff.							
a 5%	N. S.	N. S.	0.51	2.33	N. S.	N. S.	51.31
a 1%	—	—	0.67	3.07	—	—	67.54

The yields of wheat were depressed most by spraying at the boot and bloom stages (Table III). All concentrations at these stages gave yields which were significantly (1 per cent) less than those given at tillering stage. The treatments applied at tillering stage also proved significantly superior for fertile spikelets and grain number per ear while there was no significant difference for fertile shoots and dry matter per plot. The treatment effects at boot and bloom stages did not differ appreciably for all the characters.

Table 4 indicates the mean values of the total nitrogen contents of wheat grain under different treatments expressed as percentage of the dry weight. Nitrogen content of grains from the treated plots were higher than those from the weeded and unweeded checks. Among the spray treatment, the content was lower under 3·25 pound rate, while 4.88 and 6.50 pound rates showed more or less similar effects. However, weeded check showed 7.2 per cent more nitrogen than unweeded one. The treatments applied at earlier stages (tiller and boot) showed slight prominence over that at later stage (bloom). On an average the increase in nitrogen content of grains from weed free plots over that of unweeded one was marked by 13.7, 14.7 and 9.5 per cent at tiller, boot and bloom stages respectively.

DISCUSSION

From the data of the experiment it is evident that irrespective of species the susceptibility of all the weeds (Table I) to herbicide is greatest at the tillering stage of the crop. The increased concentrations had brought higher percentage of kill. Roberts and Blackman (20) have also reported greatest susceptibility of all the annual weeds under experimentation in the young seedling stage. Further Blackman and Holly (3) observed a reduction in degree of weed control from 84.5 to 74.4 per cent; if spraying was delayed. Templeman and Halliday (21) in their experiment of weed control with M. C. P. A. observed that, except in the case of certain species, applications prior to emergence or at the very young seedling stage generally gave the best results. Pavlychenko (16) has also reported that all annual weeds under observations developed a steady resistance from the flowering to the maturity. High mortality of weeds in wheat field treated with different formulations of 2, 4-D at tillering stage has been earlier reported by Pande (17).

The extent to which the yield of a crop is increased following the eradication of the weed population, is dependent on the intensity and duration of weed population, and this in turn is dependent on a number of factors. Yield increases are likely to be greater when the weeds are removed in the young seedling stage and minimum when control is left until the weeds are in full flower. Normally high infestation of weeds (Table I) brought severe competition between crop and weeds and which ultimately retarded crop growth and decreased yield (Table II). The weeded plots showed significant (1 per cent) increase in yield over unweeded one. The crop plants succeeded in producing more because they became free from competition with associated weeds after the plots were weeded out. Similar effects with cereals were observed by Blackman and Templeman (4), Godel (7), Mann and Barnes (13), Pavlychenko and Harrington (15) and Pande (19). In the present experiment the weed density was extremely high as they constituted 90.5 per cent of the total population. However, any treatment for eliminating the weeds and reducing the competition could bring appreciable increase in grain yield, provided the treatment had no adverse effect on the crop. Willard (23) is also of opinion that such treatments usually give profitable results only when the weed infestation is high and the crop is unable to provide normal competition with weeds.

TABLE IV

Inter-relationship between stage of development and the nitrogen content of wheat grain to different treatments

Treatment	Tiller: N. content as % dry wt.	Tiller: Increase over unweeded check %	Boot: N. content as % dry wt.	Boot: Incr. over unweeded check %	Bloom: N. content as % dry wt.	Bloom: Incr. over unweeded check %	Mean: N. content as % dry wt.	Mean: Incr. over unweeded check %
Sod. dichloro phenoxyacetate								
3.25 lb/acre	1.92	10.3	2.02	16.1	1.83	5.1	1.92	10.5
4.88 „	1.99	14.3	2.10	20.6	2.00	14.9	2.03	16.6
6.50 „	2.09	20.1	2.05	17.8	1.93	10.9	2.03	16.2
Weeded check	1.92	10.3	1.82	4.6	1.86	6.9	1.86	7.2
Unweeded „	1.74	...	1.74	...	1.74	...	1.74	...
Mean	1.93	13.7	1.94	14.7	1.87	9.5		

TABLE V

Interaction between stage of development and treatments on production of fertile spikelets.

Treatment	Number of fertile Spikelets per ear: Tiller	Boot	Bloom	Increase over unweeded check: Tiller	Boot	Bloom	C.D.
Sod. dicholoro phenoxyacetate							
3.25 lb/acre	16.0	14.8	14.3	1.5	—0.4	—0.5	5% 0.85
4.88 „	15.6	13.7	14.2	1.1	—1.5	—0.6	1% 1.40
6.50 „	15.8	13.7	13.9	1.3	—1.5	—0.9	
Weeded check	16.9	16.1	15.7	2.4	0.9	0.9	
Unweeded check	14.5	15.2	14.8				

TABLE VI

Inter-relationship between stage of development and treatments on production of sterile spikelets.

Treatment	Tiller: No. of sterile spikelets per ear	Tiller: Incr. over weeded check %	Boot: No. of sterile spikelets per ear	Boot: Incr. over weeded check %	Bloom: No. of sterile spikelets per ear	Bloom: Incr. over weeded check %	Mean: No. of sterile spikelets per ear	Mean: Incr. over weeded cceck %
Sod. dichloro phenoxyacetate								
3.25 lb/acre	1.8	5.8	2.2	10.0	2.3	4.5	2.1	6.8
4.88 „	2.0	17.6	2.7	35.0	2.8	27.2	2.5	26.6
6.50 „	1.9	11.7	2.8	40.0	2.9	31.8	2.5	27.8
Unweeded check	2.2	29.4	2.3	15.0	2.4	9.0	2.3	17.9
Weeded check	1.7	—	2.0	—	2.2	—	1.9	—
Mean	1.9	—	2.4	—	2.5	—		

Plots treated with higher concentrations (4.88 and 6.50 pound/acre) produced significantly (5 per cent) lower yield than did the weeded check, whereas there was no significant difference for fertile shoots per plot. It is clear from Table II that the spray treatments caused significant reduction in fertile spikelets and grain number per ear and this ultimately resulted in significant decrease in grain yield per plot. The decrease in fertile spikelets was due to greater sterility of florets. Table VI indicates that all the concentrations at boot and bloom stages caused large amount of sterility with greatest one occurring in plots sprayed with 4.88 and 6.50 pound rates of Fernoxone. Blackman and Roberts (2) are of opinion that any gain in yield consequent upon weed elimination is a resultant of two opposing trends, a beneficial effect due to removal of weed and a possibly adverse effect of the herbicbide on the crop. The injurious effects are maximum at the higher concentrations and when spraying is delayed. They further emphasize that the greatest selectivity is obtained when the concentration does not exceed 2-3 pound/acre. All the three treatments of spraying did not show significant increase in grain yield over unweeded check though the number of fertile shoots per plot were significantly more. The probable reason may be the increased sterility at bloom and boot stages (Table VI). It is further elucidated from Table V, which shows the interaction effect between treatment and stages for fertile spikelets. It is concluded that the crop plants were susceptible to herbicidal toxicity only at boot and bloom stages of their growth, as the effect of the spray treatments at tillering was marked with significant increase in fertile spikelets and grain number per year and grain yield per plot (Table III). It is also evident from Table VII that at tillering there was no appreciable difference among spray treatments and weeded check, for the relative grain yield as percentage of control, while the differences were highly marked at boot and bloom stages. Klingman (9) has also reported that the yields of spring wheat were depressed most by spraying at the early boot stage and reductions in yields were mostly due to the large amount of sterility. Leggett (11) reported that in the two later stages of wheat, treated with 3, 4, and 5 pounds of acids in all formulations, the percentage of sterile florets ranged from 15 to 60 per cent as the concentration increased. Similar were the findings of Willard (24).

TABLE VIII.

Relative grain yield percentage of unweeded check under different treatments at three stages of crop growth.

Treatment	Stages of development Relative grain yield per plot (6'x6')		
	Tiller	Boot	Bloom
	% of unweeded check	% of unweeded check	% of unweeded check
Sod. dichloro-3phenoxyacetate. .25 lb./acre	141.5	104.8	105.0
488 ,,	139.3	102.3	103.6
6.50 ,,	142.1	95.5	102.0
Hand-weeded	145.3	129.5	127.9

It is evident that none of the spray concentrations, applied at the three stages, affected the vegetative growth of the crop as the treated plots produced significantly greater number of fertile shoots and more dry matter per plot than the unweeded check (Tables II and III). From the present investigation it is also concluded that the spray applications of Fernoxone upto 6.50 pound/acre had no deleterious effect on crop when sprayed at tillering, rather appreciable increase in yield was obtained. The delayed applications, no doubt, resulted in marked decrease. Templeman and Halliday (22) also reported that M. C. P. A. sodium salt could be applied on weed-free crops as dust or spray at rates upto 8 pound/acre to wheat, barley and oats from 3 to 8 in. high without adversely affecting yields. In some instances due to weed control by M. C. P. A., they obtained an increase in yield by 7-10 cwts. per acre. On the other hand Overland and Rasmussen (14) have reported marked decrease in yield of wheat when sprayed with ? pound rate of 2, 4-D.

The nitrogen contents of grain from the weed controlled plots were higher than those where weeds were present. Among the weed free plots, grains from the treated plots showed higher nitrogen content than those from the hand-weeded one, and the higher concentrations were more effective. Helgeson *et al.* (8) earlier reported that the protein content of grain from bread wheat was slightly increased by 2, 4-D esters while that of *durum* wheat was decreased by amine and sod. salt. Ericksion, Seily and Klagse

(6) also reported increase in protein content in several wheat varieties in direct relation to the amount of 2, 4-D applied. These increases in protein content occurred with all types of material, whether or not weeds were present and regardless of decrease or increase in grain or straw yield. On the other hand Overland and Rasmussen (14) have reported that the application of 2, 4-D had no effect on the nitrogen content of two wheat varieties under observation.

SUMMARY

Results of the application of sodium dichloro-phenoxyacetate in three concentrations (3.25,4.88 and 6.50 pound rates) and at three (tiller, boot and bloom) stages of wheat growth on mortality of weeds and development, yield and quality of grain in wheat have been presented.

At earlier stages of weed growth, even the lowest spray concentration (3.25 pound rate) brought more than 80 per cent. kill of all the weeds except *Cyperus rotundus*. With advanced stage of development, all the weeds showed slight resistance to the toxic effect of the herbicide. Increased concentrations were more effective.

All the three spray concentrations applied at tillering phase of wheat growth proved equally effective to that of hand-weeding in increasing grain yield. Applications at later stages significantly decreased the yield due to higher sterility of florets. The toxic effect of 3.25 pound rate was, to some extent, mild.

Applications of the herbicide up to 6.50 pound/acre did not affect the vegetative growth of the crop; nervertheless significant increases in dry matter and fertile shoots over unweeded check were obtained.

The nitrogen content of the grain from the weed-free plots were higher. The spray treated plots showed higher nitrogen than the hand-weeded one and the increase in concentrations was associated with increase in nitrogen content. Treatments at earlier stages proved, somewhat, better than those at later one.

ACKNOWLEDGMENT

My grateful thanks are due to my Professor, Dr. N. K. Anant Rao, under whose guidance these investigations are being done.

REFERENCES

1. Blackman, G. E. and H. A. Roberts. 1950. *J. agric. Sci.*, **40** : 63-69.
2. Blackman, G. E. and H. A. Roberts, 1950. *J. agric. Sci.*, **40** : 70-81.
3. Blackman, G. E. and K. Holly. 1949. *J. Minist. Agric.*, **55** : 6-11.
4. Blackman, G. E. and W. G. Templeman. 1938. *J agric. Sci.*, **28** : 247-71.
5. Elder, W. C., 1947. Proc. 4th. *Ann. Meeting North-Central Weed Control Conf.*, p. 217.
6. Erickson, L. C., C. I. Seily and K. H. Klages, 1948. *J. Amer. Soc. Agron.* **40** : 650.
7. Godel, G. L., 1935. *Sci. Agric.*, **16** : 165-68.
8. Helegeson et al., 1948. *L. D. N. Dakota Agric. expt. Sta. Bimonthly Bull.*, **10** : 166-71.
9. Klingman, D. L., 1947. Proc. 4th. *Ann. Meeting, North-Central Weed Control Conf.*, pp. 31-32.
10. Klingman, D. L., 1947. *Amer. soc. Agron.*, **30** : 445-47.
11. Leggett, H. W., 1947. *Proc. 4th. Ann. Meeting, North-Central Weed Control Conf.* p. 220.
12. McNeal, F. H., 1948. *J. Amer. Soc. Agron.*, **40** : 1070-3.

13. Mann, H. H. and T. W. Barnes, 1945. *Ann. appl. Biol.*, **32** : 15-22.
14. Overland, A. and L. W. Rasmussen, 1951. *Agron. J.* **43** : 321-4.
15. Pavlychenko, T. K. and J. B. Harrington, 1934. *Cand. J. Res.*, **10** : 77-94.
16. Pavlychenko, T. K., 1937. *Proc. 4th. Ann. Meeting, North-Central Weed Control Conf.* p. 42.
17. Pande, H. K., 1952. *Agric. A. H. U. P.*, **2** : No. 7.
18. Pande, H. K., 1953. *Agra Univ. J. Res.* **2**(Sci.) : 41-44.
19. Pande, H. K., 1953. *Empire J. Expt. Agric.* (appearing in October No.)
20. Roberts, H. A. and Blackman, G. E. 1950. *J. agric. Sci.* **40** : 263-74.
21. Templeman, W. G. and D. J. Halliday,' 1950. *Empire J. Expt. Agric.* **18**: 19-30.
22. Templeman, W. G. and D. J. Halliday, 1950. *Empire J. Expt. Agric.* **18** : 169-76.
23. Willard, C. J., 1947. *Proc. 4th Ann. Meeting, North-Central Weed Control Conf.*, p. 149.
24. Willard, C. J., 1947. *Proc 4th Ann. Meeting, North-Central Weed Control Conf.*, p. 222.
25. Yates, F., 1937. The Design and Analysis of Factorial Experiment. Imperial Bureau of Soil Science.

CATALOGUE OF ORIENTAL BETHYLOIDEA*

By CHANDY KURIAN, M. Sc., F. R. E. S., *Research Associate, School of Entomology, St. John's College, Agra.*

This catalogue includes the species described upto 1952 from the Oriental Region. An attempt has been made to bring the references up-to-date. My sincere thanks are due to Dr. M. S. Mani, Professor of Zoology and Entomology, School of Entomology, St. John's College, Agra, for facilities of work and guidance.

Superfamily BETHYLOIDEA.

Proctotrupi (partim), LATREILLE, *Gen. Crust. Ins.*, **4** : 39 (1809).
Proctotrypides (partim), LEACH, *Edinb. Enc.*, **9** : 145 (1815).
Mutillidae (partim), LEACH, *Edinb. Enc.*, **9** : 147 (1815).
Oxyura (partim), HALIDAY, *Ent. Mag.*, **1** : 273 (1833).
Dryinidae, HALIDAY, *in F. Walker Ent. Mag.*, **4** : 411 (1837).
Cenoptera, HALIDAY, *Hym. Brit. Syn.*, p. 3 (1839).
Gonatopides, WESTWOOD, *Intr. Classif. Ins.*, **2** : 75-76 (1840).
Proctotrypidae (partim), MARSHALL, *Cat. Brit. Mus.*, p. 1. (1873).
Vespoidea (partim), ASHMEAD, *Canad. Ent.*, **34** : 146 (1902).
Bethylidae, KIEFFER, *Das Tierreich*, **41** : 1-595 (1914), [Monographic revision of World forms, with tables of subfamilies, genera and species]. WHITTAKER, *Trans. ent. Soc. London*, **76** (2) pp. 385-390, 1pl. (1929), [New Bethylidae from British Columbia]. NIELSEN, *Ent. Meddel (Copenhagen)*, **18**(1) pp. 1-57 (1932), [Review of behaviour]. RICHARDS, *Proc. Roy. ent. Soc. London*, (B) **5**(9)pp. 169-173 (1936), [Notes on Nomenclature]; *Trans. Roy. ent. Soc. London*, **89** : 185-343, IIIfigs. (1939), [The British Bethylidae. Key for separating British Bethylidae from other Clistogastra. A revised check list of British species].

Bethyloidea, PRUTHI and MANI, *Mem. Indian Mus.*, **13**(4) pp. 423-444 (1942), [Notes on biology and distribution of Indian Bethyloidea]. MUESEBECK and WALKLEY, *U. S. Dept. Agric. (Agric. Mon.)*, **2** : 726-734 and 1034-1043 (1951), [Synoptic catalogue of Bethyloidea of America north of Mexico].

Family 1. DRYINIDAE.

Dryinidae, DALMAN, *Kongl. Vet.-Acad. Handl.* pp. 81-88 (1818). (partim), WALKER, *Ent. Mag.*, **4** : 411 (1837). KIEFFER, *Ztschr. wissensch. Ins.-Biol.*,

---

*Contribution No. 44 from the School of Entomology, published with the permission of the Professor of Zoology and Entomology.

1 : 6-13 (1905). Perkins, *Rep. expt. Stat. Hawaii, Ent. Bull.*, **1**(1) pp. 10-26 (1905), [Biology—Leaf-hoppers and their natural enemies]; *Ibid*, **4** (1907), [Parasites of leaf-hoppers]. Brues, *Conn. N.H. Suro. Bull.*, **22**:608-616 (1916), [Revision of Dryinidae]. Haupt, *Ztschr. f. Naturw.*, **12**:217-223 (1916), [Biology: contribution to the knowledge of enemies of Cicada]. Fenton, *Ohio Journ. Sci.*, **18** : 182-257 (1918), [Biology]. Hellen, *Med. Soc. Fauna Flora Fennica*, p. 277-290 (1919); *Ibid*, **45** : 278-290 (1920), [Notes on Finnish Dryinids]. Berland, *Fauna de France*, **19**(8) pp. 1-208 (1928), [Monograph on the Family with key to French genera and species]. Haupt, *Zool. Anz.*, **99** (1 & 2) pp. 1-18 (1932), [Morphology, Homology of mouthparts of *Aphelopus* with Trilobita and Crustacea]. Richards, *Journ. ent. Soc. South of England*, **1** : 51-52 (1933); *Trans. Roy. ent. Soc. London*, **83** (1) pp. 147-156 (1935). Arle, *Boll. Mus. nac. Rio. de J.*, **11** (3-4) pp. 51-55 (1935), [Dryinid larva and larval case]. Richards, *Ann. Mag. Nat. Hist.*, (10) **18** : 463-467 (1936), [The Cameron collection of Dryinidae]. Haupt, *Ztschr. f. Naturw.*, **91** (2) pp. 69-77 (1937), [Biology of *Lestodryinus*]; *Ibid*, **92** : 13-35 (1938), [Key to subfamilies and genera and biology]. Richards, *Trans. Roy. ent. Soc. London*, **89** : 188-230 (1939), [Classification and biology of Dryinidae]. Reid, *Trans. Roy. ent. Soc. London*, **91** : 409-412 (1941), [Morphology]. Haupt, *Ztschr. f. Naturw.*, **95** : 27-67 (1941); *Stett. Ent. Ztg.*, **105** : 90-94 (1944). Muesebeck and Walkley, *U. S. Dept. Agric. (Agric. Mon.)*, **2** : 1034-1043 (1951), [Synoptic Catalogue of Hymenoptera of America North of Mexico]. Richards, *Trans. Roy. ent. Soc. London*, **104** (4) pp. 51-70 (1953), [Classification of Dryinidae with description of new species].

Dryininae, Haliday, *Hym. Syn.*, p. 3 (1839).

Dryinoidea, Forster, *Hym. Stud.*, **2** : 94 (1856).

Dryinini, Thomson, *Ofv. Ak. Forh.*, **17** : 175-181 (1860).

Oxyura (partim), Cameron, *Ann. Scott. Nat. Hist. Edinburg*, (1) **61** : 31-34 (1907).

Anteonidae, Kieffer, *Bull. Soc. Metz.*, **27** : 108 (1911). Pruthi and Mani, *Mem. Indian Mus.*, **13** (4) pp. 423-428 (1942), [Notes on biology of Dryinidae].

Anteoninae, Kieffer, *Bull. Soc. ent. France*, pp. 300-301 (1913); *Das Tierreich*, **41** : 6-25 (1914), [Key to subfamilies]. Ogloblin, *Acta ent. Pragae*, **2** : 117-131 (1925).

Subfamily 1. DRYININAE.

Dryininae, Ashmead, *U. S. Nat. Mus. Bull.*, **45** : 16-20, 80-101 (1893), [Morphology and taxonomy]. Swezey, *Ohio Naturalist*, **3** : 448-451 (1903), [Morphology]. Kieffer, *Gen. Ins.*, **54** : 3 (1907). (partim); Haupt, *Ztschr. f. Naturw.*, **92** : 16-21 (1938), [Key to genera of Dryininae].

Lestodryinini, Kieffer, *Das Tierreich*, **41** : 11 (1914), [Key to genera].

Dryinidae, Haupt, *Ztschr. f. Naturw.*, **91** (2) pp. 70-77 (1937), [Biology of *Lestodryinus*].

Dryinini, Richards, *Trans. Roy. ent. Soc. London*, **89** : 227 (1939), [British Genera and species of Dryinini]. Muesebeck and Walkley, *U. S. Dept. Agric.*

(*Agric. Mon.*), **2** : 1034-1039 (1951), [Synoptic Catalogue of North American species].

Lestodryininae, PRUTHI and MANI, *Mem. Indian Mus.*, **13** (4) pp. 423-426 (1942), [Notes on biology of Lestodryininae].

Genus 1. **Lestodryinus** Kieffer.

Dryinus (partim), LATREILLE, *Hist. Crust. Ins.*, **13** : 228 (1805). KIEFFER, *Andre, Spec. Hym. Eur.*, **9** : 69 (1905).

Ceraphron, KLUG, *Mag. Ges. Fr. Berlin*, **2** : 49 (1808).

Lestodryinus, KIEFFER, *Bull. Soc. Metz.*, **27** : 108 (1911), [Genotype : *Lestodryinus formicarius* (Latreille)]; *Das Tierreich*, **41** : 21 (1914). MANEVAL, *Ann. Soc. Ent. France*, **104** (1) pp. 1-10 (1935), [*Lestodryinus formicarius*, parasite of *Cixius nervosus* in France].

browni (Ashmead).

Dryinus browni, ASHMEAD, *Proc. U. S. Mus.*, **29** : 109 (1905)[1], [Parasitic on Fulgoridae or Membracidae].

Lestodryinus browni, KIEFFER, *Das Tierreich* **41** : 24 (1914)[1].

[1] Manila, Luzon : Philippines.

kiefferi Fouts.

Lestodryinus kiefferi, FOUTS, *Philipp. J. Sci.*, **20** : 630 (1922)[1].

[1] Mount Maquiling, Luzon : Philippines.

luzonicus Kieffer.

Lestodryinus luzonicus, KIEFFER, *Boll. Laborat. Zool. Portici*, **7** : 189 (1913)[1]; *Das Tierreich*, **41** : 24 (1914).

[1] Berg Makiling, Luzon : Philippines.

perkinsi Kieffer.

Lestodryinus perkinsi, KIEFFER, *Bull. Soc. ent. France*, p. 90 (1914)[1]; *Das Tierreich*, **41** : 23 (1914).

[1] Los Banos : Philippines.

pyrillae Kieffer.

Lestodryinus pyrillae, KIEFFER, *Bull. Soc. Metz*, **27** : 108 (1911)[1]; *Das Tierreich*, **41** : 22 (1914)[2], [Host : *Pyrilla aberrans*, *Pyrilla perpusilla* and *Pyrilla pusana*]. PRUTHI and MANI, *Mem. Indian Mus.*, **13** (4) pp. 423-425 (1942).[3]

[1] Bengal : India.

[3] Pusa, Bihar; Delhi, Punjab; South India: India.

Dryinus pyrillae, MISRA, *Mem. Dept. Agric. India, Ent. Ser.*, **5** : 114-115 (1917).[2]

[2] Pusa, Bihar : India.

stantoni (Ashmead).

Dryinus stantoni, ASHMEAD, *Proc. U. S. Nat. Mus.*, **28** : 134 (1904).

Prodryinus ? stantoni, KIEFFER, *Andre, Spec. Hym. Eur.*, **9** : 498 (1906)[1]; *Das Tierreich*, **41** : 53 (1914).

[1] Manila, Luzon : Philippines.

Lestodryinus stantoni, FOUTS, *Philipp. J. Sci.*, **20** : 629 (1922)[1].

trifasciatus (Kieffer).

Dryinus trifasciatus, KIEFFER, *Z. Hym. Dipt.*, **6** : 335 (1906)[1].
Lestodryinus trifasciatus, KIEFFER, *Bull. Soc. Metz.*, **27** : 109 (1911); *Das Tierreich*, **41** : 22 (1914).

[1] India.

Genus 2. **Mesodryinus** Kieffer.

Dryinus (partim), MARSHALL, *Ent. monthly Mag.*, **10** : 207 (1874).
Mesodryinus, KIEFFER, *Andre, Spec. Hym. Eur.*, **9** : 497 (1906), [Genotype : *Mesodryinus niger* (Kieffer)]; *Das Tierreich*, **41** : 29 (1914), [Key to species]. PRUTHI and MANI, *Mem. Indian Mus.*, **13** (4) p. 425 (1942).

indicus Kieffer.

Mesodryinus indicus, KIEFFER, *Rec. Indian Mus.*, **10** : 311 (1914)[1], [Host : Nymphs of fulgorid *Phromnia marginella*]. PRUTHI and MANI, *Mem. Indian Mus.*, **13** : 424 (1942)[1].

[1] Pusa, Bihar: India.

Genus 3. **Paradryinus** Perkins.

Paradryinus, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **1** : 53 (1905), [Genotype : *Paradryinus koebelei* Perkins]; *Ibid*, **11** : 10-12 (1912). KIEFFER, *Das Tierreich*, **41** : 33 (1914), [Key to species].

hospes Perkins.

Paradryinus hospes, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **11** : 12 (1912)[1].

[1] Philippines.

javanus Perkins.

Paradryinus javanus, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **11** : 11 (1912)[1]. KIEFFER, *Das Tierreich*, **41** : 34-35 (1914).

[1] Pekalongan : Java.

kevirae Lal.

Paradryinus kevirae, LAL, *Indian J. Ent.*, **1** (2) pp. 50-51, fig. 2 (1939)[1], [Host : Bred from a pupa on leaf of sugarcane].

[1] Musheri; Bihar : India.

nudus Perkins.

Paradryinus nudus, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **11** : 12 (1912)[1].

[1] Philippines.

terryi Perkins.

Paradryinus terryi, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **11** : 10 (1912)[1]. KIEFFER, *Das Tierreich*, **41** : 35 (1914).

[1] Hongkong : China.

Genus 4. **Chlorodryinus** Perkins.

Chlorodryinus, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **1** : 57 (1905), [Genotype : *Chlorodryinus palli-*

dus Perkins]. KIEFFER, *Das Tierreich*, **41** : 41 (1914).

pallidus Perkins.

Chlorodryinus pallidus, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **1** : 57 (1905)[1], [Host : Nymphs of a fulgorid, probably *Siphanta* sp.]. PRUTHI and MANI, *Mem. Indian Mus.*, **13** (4) p. 425 (1942)[2], [Host : Nymphs of *Pyrilla* sp.].

[1] Australia.
[2] Pusa, Bihar : India.

Genus 5. **Neodryinus** Perkins.

Neodryinus, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **1** : 50 (1905), [Genotype : *Neodryinus koebelei* Perkins]. KIEFFER, *Das Tierreich*, **41** : 25 (1914), [Key to species]. RICHARDS, *Trans. Roy. ent. Soc. London*, **104** (4) pp. 51-70 (1953).

Psilodryinus, KIEFFER, *Andre, Spec.* Hym. *Eur.*, **9** : 497 (1906), [Subgenus].

lawanae Richards.

Neodryinus lawanae, Richards, *Trans. Roy. ent. Soc. London*, **104** (4) pp. 64-66 (1953)[1].

[1] Kuala Lumpur : Malaya.

leptopus Richards.

Neodryinus leptopus, RICHARDS, *Trans. Roy. ent. Soc. London*, **104** (4) pp. 66-67 (1953)[1].

[1] Kuching : Borneo.

Genus 6. **Psilodryinus** Kieffer.

Dryinus (partim), KIEFFER, *Ann. Mus. Genova*, **42** : 9 (1905).

Neodryinus (subgenus Psilodryinus), KIEFFER, *Andre, Spec. Hym. Eur.*, **9** : 497 (1906). (partim), PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **2** (4) p. 38 (1907):

Psilodryinus, KIEFFER, *Das Tierreich*, **41** : 53 (1914), [Genotype : *Psilodryinus acuticollis* Kieffer]. FOUTS, *Philipp. J. Sci.*, **20** : 631 (1922).

reticulatus Fouts.

Psilodryinus reticulatus, FOUTS, *Philipp. J. Sci.*, **20** : 632 (1922)[1].

[1] Luzon ; Los Banos : Philippines.

sumatrans Enderlein.

Neodryinus sumatrans, ENDERLEIN, *Ent. Zeit. Stettin*, **68** : 325, fig. 1 (1907)[1].

Psilodryinus sumatrans, KIEFFER, *Das Tierreich*, **41**:54 (1914)

[1] Sumatra.

thoracicus Fouts.

Psilodryinus thoracicus, FOUTS, *Philipp. J. Sci.*, **20** : 630 (1922)[1].

[1] Puerto Princesa, Palawan: Philippines.

Subfamily 2. GONATOPODINAE.

Gonatopodinae, KIEFFER, *Andre*, *Spec. Hym. Eur.*, **9** : 489 (1906). PRUTHI and MANI, *Mem. Indian Mus.*, **13** (4) pp. 423-426 (1942), [Notes on biology of *Gonatopodinae*].

Gonaotpodini, KIEFFER, *Das Tierreich*, **41** : 67 (1914). RICHARDS, *Trans. Roy. ent. Soc. London*, **89**: 194 (1939), [British genera and species of Gonatopodini].

Genus 7. **Phanerodryinus** Roepke.

Phanerodryinus, ROEPKE, *Tydschr. Ent.*, **59** : 290 (1916), [Genotype : *Phanerodryinus javanus* Roepke].

javanus Roepke.

Phanerodryinus javanus, ROEPKE, *Tydschr. Ent.*, **59** : 290 (1916)[1].

[1] Java.

Genus 8. **Pseudogonatopus** Perkins.

Pseudogonatopus, PERKINS, *Rep. Expt. Stat. Hawaii*, Ent., **1** : 34 (1905), [Genotype : *Pseudogonatopus dichromus* Perkins]. KIEFFER, *Das Tierreich*, **41** : 79 (1914), [Key to species]. RICHARDS, *Trans. Roy. ent. Soc. London*, **89** : 194 (1939). MUESEBECK and WALKLEY, *U. S. Dept. Agric.* (*Agric. Mon.*), **2**: 1036 (1951), [Synoptic Catalogue of North American species].

hospes Perkins.

Pseudogonatopus hospes, PERKINS, *Rep. Expt. Stat. Hawaii*, *Ent.*, **11** : 12 (1912)[1]. KIEFFER, *Das Tierreich*, **41** : 81 (1914).

[1] Java & China.

nudus Perkins.

Pseudogonatopus nudus, PERKINS. *Rep. Expt. Stat. Hawaii*, *Ent.*, **11** : 12 (1912)[1]. KIEFFER, *Das Tierreich*, **41** : 81 (1914).

[1] Java.

pyrillae Mani.

Pseudogonatopus pyrillae, MANI, *Indian J. Ent.*, **4** (2) p. 161 (1942)[1], [Host : Nymphs of *Pyrilla* sp.].

[1] Daurala Farm, Meerut; Karnal, Punjab : India.

sogatea Rohwer.

Pseudogonatopus sogatea, ROHWER, *Proc. U. S. Nat. Mus.*, **57**: 160 (1920). MISRA, *Mem. Dept. Agric. Ind.*, (*Ent. Ser.*), **5** (5), pp. 207-239 (1920). PRUTHI and MANI, *Mem. Indian Mus.*, **13** (4) pp. 426-427, figs. 18 & 19 (1942) [1], [Host : Nymphs of Delphacid paddy leaf-hoppers,

[1] Pusa, Bihar : India.

Sogata pusana Dist., *Sogata distincta* Dist. and *Sogata pallescens* Dist.].

Genus 9. **Haplogonatopus** Perkins.

Haplogonatopus, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **1** : 39 (1905), [Genotype : *Haplogonatopus americanus* Perkins]; *Ibid*, **2** (4) p. 9 (1907). KIEFFER, *Das Tierreich*, **41** : 88 (1914).

eristatus Kieffer.

Haplogonatopus eristatus, KIEFFER, *Philipp. J. Sci.*, **20** : 67 (1922) [1].

[1] Cuernos Mountain, Negros : Philippines.

orientalis Rohwer.

Haplogonatopus orientalis, ROHWER, *Proc. U. S. Nat. Mus.*, **57** : 159 (1920)[1]. MISRA, *Mem Dept. Agric. Ind.*, (*Ent. Ser.*), **5** (5) pp. 207-239 (1920)[1]. PRUTHI and MANI, *Mem. Indian Mus.*, **13** (4) p. 428 (1942)[1], [Host : Nymphs of *Sogata sp.* on paddy leaves].

[1] Janjgir, Bilaspur; Orissa : India.

Genus 10. **Gonatopus** Ljungh.

Gonatopus, LJUNGH, *Beitr. Naturk.*, **2** : 161 (1810), [Genotype : *Gonatopus formicarius* Ljungh]. KIEFFER, *Andre, Spec. Hym. Eur.*, **9**: 487 (1906). SAHLBERG, *Acta Soc. Fauna Flora Fennicæ*, **33** : 3-19 (1910). PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **11** : 13 (1912). KIEFFER, *Das Tierreich*, **41** : 103 (1914). HAUPT, *Ent. Gesell. Halle Mitt.*, **10** : 41-50 (1916), [Biology]. STRAND, *Ent. Mitt. Deutsch. Ent. Mus. Berlin Dahlem*, **8** : 201-207 (1919). HAUPT, *Zool. Anz.*, **99** : 13 (1932), [Morphology of larva]. RICHARDS, *Trans. Roy. ent. Soc. London*, **89** : 185-344 (1939), [Revision]. MUESEBECK and WALKLEY, *U. S. Dept. Agric.* (*Agric Mon.*), **2** : 1037-1038 (1951), [Synoptic Catalogue of North American species].

schenklingi Strand.

Gonatopus Schenklingi, Strand, *Ent. Mitt.*, **2** : 210 (1913)[1]. KIEFFER, *Das Tierreich*, **41** : 119 (1914).

[1] Formosa.

Genus 11. **Digonatopus** Kieffer

Gonatopus, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **1** : 41 (1905).

Docindylus, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, **11** : 14 (1912).

Digonatopus, Kieffer, *Boll. Laborat. Zool. Portici*, **7** : 325 (1913), [Genotype : *Digonatopus javanus* (Perkins)]; *Das Tierreich*, **41** : 134 (1914), [Key to species].

javanus (Perkins).

Dicondylus javanus, Perkins, *Rep. Expt. Stat. Hawaii, Ent.*, **11** : 15 (1912) [1].

Digonatopus javanus, Kieffer, *Boll. Laborat. Zool. Portici*, **7** : 325 (1913) ; *Das Tierreich*, **41** : 135 (1914)[1], [Host : Obtained from *Deltocephalus*].

[1] Pekalongan : Java.

lucidus Rohwer.

Digonatopus lucidus, Rohwer, *Proc. U. S. Nat. Mus.*, **57** : 159 (1920). Pruthi and Mani, *Mem. Indian. Mus.*, **13** (4) p. 428 (1942)[1], [Host: Nymphs of *Nephotettix bipunctatus* (Fabr.)].

[1] Pusa, Bihar : India.

perpolitus (Perkins).

Dicondylus perpolitus, Perkins, *Rep. Expt. Stat. Hawaii, Ent.*, **11** : 14 (1912)[1].

Digonatopus perpolitus, Kieffer, *Das Tierreich*, **41** : 134 (1914)[1].

[1] Pekalongan : Java.

plebeius (Perkins).

Dicondylus plebeius, Perkins, *Rep. Expt. Stat. Hawaii, Ent.*, **11** p. 15 (1912).

Digonatopus plebeius, Kieffer, *Das Tierreich*, **41** : 135 (1914)[1], [Host : Nymph of a Jassid].

[1] Pekalongan : Java.

Subfamily 3. ANTEONINAE.

Anteoninae, Kieffer, *Andre, Spec. Hym. Eur.*, **9** : 510 (1906). Fenton, *Ohio Nat.*, **19** : 177-212 & 243-278 (1918), [Biology]; *Proc. U. S. Nat. Mus.*, **72** (8) pp. 1-16 (1927). Haupt, *Ztschr. f. Naturw.*, **95** : 27-67 (1941), [Biology, characters of the subfamily, key to genera etc.].

Anteonini, Keiffer, *Das Tierreich*, **41**: 137 (1914), [Key to genera]. Richards, *Ann. Mag. Nat. Hist.*, **18** (106) pp. 463-467 (1936), [Designation of Holotypes etc. of Kieffer's species]; *Trans. Roy. ent. Soc. London*, **89** : 230 (1939), [British genera and species of Anteoninae]. Muesebeck and Walkley, *U. S. Dept. Agric. (Agric. Mon.)*, **2** : 1040-1042 (1951), [Synoptic Catalogue of North American species].

Genus 12. **Allodryinus** Kieffer.

Allodryinus, Kieffer, *Philipp. J. Sci.*, **20** : 65 (1922), [Genotype : *Allodryinus miripes* Kieffer].

miripes Kieffer.

Allodryinus miripes, Kieffer, *Philipp. J. Sci.*, **20** : 66 (1922)[1].

[1] Luzon ; Mindanao; Negros; Leyte & Palawan : Philippines.

Genus 13. **Neoanteon** Fouts.

Neoanteon, Fouts, *Philipp. J. Sci.*, **20** : 633-634- (1922), [Genotype : *Neoanteon rubrica* Fouts].

rubrica Fouts.

Neoanteon rubrica, Fouts, *Philipp. J. Sci.*, **20**: 634-635 (1922)[1].

[1] Luzon; Los Banos : Philippines.

Family 2. BETHYLIDAE.

Dryinidae (partim), Haliday, *F. Walker. Ent. Mag.*, **4** : 411 (1837).

Bethylidae, Haliday, *Hym. Brit. Syn.*, p. 3 (1839). Brues, *Conn. N. H. Surv. Bull.*, **22** : 508-616 (1916), [Revision of Bethylidae of Connecticut]. Hellen, *Medd. Soc. Faun. Fl. Fenn.*, **45** : 278-290 (1920), [Notes on Finnish Bethylids]. Berland, *Faune de France*, **19** (8) pp. 1-208 (1928), [A monograph on the family with keys to French genera and species]. Turner, *Ann. Mag. Nat. Hist.*, **1** (1) pp. 129-152 (1928), [African species]. Richards, *Journ. ent. Soc. South of England*, **1** (3) pp. 51-78 (1933), [Notes on British Bethylidae]. Fouts, *Mem. Soc. Ent. Ital.*, **13** (1) pp. 98-109 (1934), [Bethylidae from Italian Somaliland]. Muesebeck, *Rec. Indian Mus.*, **36** (2) pp. 223-232, 2 fig. (1934), [Seven new species of Indian Bethylidae]. Richards, *Trans. Roy. ent. Soc. London*, **89** : 185-344 (1839), [Key to the British genera and species of Bethylidae]. Reid, *Trans. Roy. ent. Soc. London*, **91** : 402-409 (1941), [Morphology]. Muesebeck and Walkley, *U. S. Dept. Agric.* (*Agric. Mon.*), **2** : 726-734 (1951), [Synoptic Catalogue of North American species].

Gonatopides (partim), Westwood, *Intr. Classif. Ins.*, **2** : 76 (1840).

Bethyloidae, Forster, *Hym. Stud.*, **2** : 93 (1856).

Epyrini, Thomson, *Ofv. Ak. Forh.*, **18** : 451 (1862).

Bethylinae, ASHMEAD, *Bull. U. S. Nat. Mus.*, **45** : 16-20 & 27-76 (1893), [Biology and Taxonomy]. KIEFFER, *Das Tierreich*, **41** : 228 (1914).

Subfamily 1. SCLERODERMINAE.

Sclerodermini, KIEFFER, *Das Tierreich*, **41** : 238 (1914).

Genus 14. **Dryinopsis** Brues.

Dryinopsis, BRUES, *J. ent. Soc. New York*, **18** : 16 (1910), [Genotype : *Dryinopsis simplicipes* Brues]. KIEFFER, *Das Tierreich*, **41** : 240 (1914).

simplicipes Brues.

Dryinopsis simplicipes, BRUES, *J. ent. Soc. New York*, **18** : 17 (1910)[1]. KIEFFER, *Das Tierreich*, **41**: 241 (1914)[1].

Genus 15. **Cephalonomia** Westwood.

Cephalonomia, WESTWOOD, *Mag. Nat. Hist.*, **6** : 420 (1833), [Genotype : *Cephalonomia formiciformis* (Westwood)]; *Trans. ent. Soc. London*, p. 125 (1881). KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 449 (1906). KIEFFER, *Das Tierreich*, **41** : 242 (1914), [Key to species]. HAMM, *Proc. Ent. Soc.*, p. 26 (1922), [Life-history]. SARRA, *Boll. Laborat. Zool. Portici*, **24** : 223-227 (1930), [*Cephalonomia nigricornis* parasitic on larvae of *Eccoptogaster amygdali*, *Scolytus rugulosus* and *Tenebriodes mauritanicus* in Italy]. GAHAN, *Journ. Washington Acad. Sci.*, **21** (10) pp. 213-221 (1931), [Parasites of stored grain insects and morphology and biology of *Cephalonomia quadridentata*]. VAN EMDEN, *Ztschr. Morph. u. okol. Tiere*, **23** : 425-574 (1931), [Biology of *Cephalonomia caesarorum* Van Emden and *Cephalonomia quadridentata* Duchaussoy & morphology]. GRANDI, *Lab. Ent. R. Ist. Sup. Agr. Bologna Bol.*, **5** : 113-115 (1932), [Morphology]. RICHARDS, *Journ. ent. Soc. South of England*, **1** (3) pp. 51-78 (1933), [*Cephalonomia tarsalis* (Ashm.) found in London warehouses where it parasitises larvae of the beetles *Oryzaephilus surinamensis* and *Oryzaephilus mercator*]. KEARNS, *Journ. Econ. Ent.*, **27** (4) pp. 801-806 (1934), [Biology—*Cephalonomia gallicola* Ashmead parasi-

[1] North Borneo.

tising cigarette beetle *Lasioderma serricorne*]. GUSAKOVSKII, *Rev. Ent. U. R. S. S.*, **25** : 229 & 459 (1935), [*Cephaloderma* subgen. nov.]. MANEVAL, *Ann. Soc. Ent. France*, **104** (1) pp. 1-10 (1935), [*Cephalonomia sulcata* a new parasite of the coleopteran *Ennerarthron affine* in France]. POWELL, *Ent. Soc. Amer. Ann.*, **31**: 44-49 (1938), [Biology of *Cephalonomia kiefferi* Fouts]. MUESEBECK and WALKLEY, *U. S. Dept. Agric. (Agric. Mon.)*, **2** : 727 (1951), [Synoptic Catalogue of North American species, north of Mexico].

Holopedina, FORSTER, *Verh. Ver. Rheinlande*, **7** : 502 (1850).

Gonatopus, J. LICHTENSTEIN, *Bull. Soc. ent. France*, **5** (4) p. 31 (1874).

indica Kieffer.

Cephalonomia indica, KIEFFER, *Z. Hym. Dipt.*, **7** : 313 (1907)[1]; *Das Tierreich*, **41** : 248 (1914). [1]Java.

peregrina Westwood.

Cephalonomia ? peregrina, WESTWOOD, *Trans. ent. Soc. London*, p. 127, pl. 6, fig. 5 & 6 (1881)[1]. KIEFFER, *Das Tierreich*, **41** : 248 (1914). [1]Ceylon.

Genus 16. **Scleroderma** Latreille.

Sclerodermus, Klug : LATREILLE, *Gen. Crust. Ins.*, **4** : 118 (1809). KIEFFER, *Das Tierreich*, **41** : 253 (1914), [Key to species etc.]. BRIDWELL, *Proc. Hawaii ent. Soc.*, **4** : 291-305 (1920), [Natural History]. BRYAN, *Jr. et. all. Insects of Hawaii*, p. 21 (1928), [Key to Hawaiian species]. YUASA, *Journ. Imp. Agric. Expt. Stat. Tokio*, **1** (3) pp. 215-230 (1930), [*Sclerodermus nipponicus* parasitic on the larvae of Anobiid beetle *Ptilineurus marmoratus* Reitter, mining in the Japanese rush mat]. PASQUIER, *Bull. econ. Indochine*, **35** : 230 (1932), [Morphology and life-history of *Sclerodermus domesticus*].

Scleroderma, OKEN, *Isis*, **8** : 1178 (1817), [Genotype : *Scleroderma domesticus* (Latreille)]. WESTWOOD, *Trans. ent. Soc. London*, **2** : 164 (1839). A. COSTA, *Annuario Mus. Zool. Napoli*, **2** : 131 (1862), [Misspelling]. BRIDWELL, *Psyche*, **36** (2) pp. 119-122 (1929), [Biology of *Scleroderma immigrans*]. BERNARD and JACQEMIN, *Bull. Soc. Hist. nat. Afr.*, **39** :

160-162 (1949), [Characters and revision of species of Mediterranean region]. MUESEBECK and WALKLEY, *U. S. Dept. Agric.* (*Agric. Mon.*), **2** : 728 (1951), [Synoptic Catalogue of North American species. Species of this genus often develop on larvae of Cerambycidae living in wood work of houses; the adult parasites have frequently been reported as stinging man].

Omalus (partim), NEES, *Hym. Monogr.*, **2** : 396 (1834).

Methoca (partim), LEPELETIER, *Ins. Hym.*, **3** : 573 (1845).

Schlerochroa, FORSTER, *Naturh. Ver. Rheinlande Verh.*, **7** : 501 (1850), [Unnecessarily proposed as a new name for *Scleroderma* Latreille].

Sclerochroa, ASHMEAD, *Ent. Amer.*, **3** : 75 (1887), [*Sclerochroa macrogaster* Ashmead, parasitises *Megacyllene antennatus* (White)].

bicolor (Fred Smith).

Sclerodermus bicolor, FRED SMITH, *J. Linn. Soc. London*, **5** : 77 (1860)[1]. KIEFFER, *Das Tierreich*, **41** : 264 (1914).

[1]Makassar, Celebes : Indonesia.

Scleroderma bicolor, WESTWOOD, *Trans. ent. Soc. London*, p. 121, pl. 5, fig. 2 (1881).

luteicollis (Kieffer).

Sclerodermus luteicolle, KIEFFER, *Ann. Mus. Genova*, **41**: 375 (1904)[1].

[1]Burma.

Sclerodermus luteicollis, KIEFFER, *Das Tierreich*, **41** : 265 (1914).

niger (Kieffer).

Sclerodermus niger, KIEFFER, *Ann. Mus. Genova*, **41** : 375 (1904)[1]; *Das Tierreich*, **41** : 265 (1914).

[1]Mentaway : Sumatra.

quadridentatus Turner and Waterston.

Scleroderma ? quadridentatus, COCKERELL, *Psyche*, **24** : 43 (1917)[1].

[1]Burma.

thwaitesianus (Westwood).

Scleroderma thwaitesiana, WESTWOOD, *Trans. ent. Soc. London*, p. 123 (1881)[1].

[1]Ceylon.

Scleroderma thwaitesianum, DALLA TORRE, *Cat. Hym.*, **5** : 560 (1898).

Sclerodermus thwaitesianus, KIEFFER, *Das Tierreich*, **41** : 264 (1914).

vigilans Westwood.

Scleroderma vigilans, WESTWOOD, *Trans. ent. Soc. London*, p. 123, pl.5, fig. 3 (1881)[1].

Sclerodermus vigilians, KIEFFER, *Das Tierreich*, **41** : 264 (1914).

[1]Ceylon.

Genus 17. **Discleroderma** Kieffer.

Scleroderma, MAGRETTI, *Ann. Mus. Genova*, **17** (2) p. 318 (1897).

Discleroderma, KIEFFER, *Ann. Mus. Genova*, **41** : 372 (1904), [Genotype: *Discleroderma tuberculatum* Kieffer]. *Ann. Soc. Sci. Bruxelles*, **27** : 106 (1905) ; *Das Tierreich*, **41** : 271 (1914).

tuberculatum (Magretti).

Scleroderma tuberculata, MAGRETTI, *Ann. Mus. Genova*, **17** (2) p. 318 (1897)[1].

Discleroderma tuberculatum, KIEFFER, *Ann. Mus. Genova*, **41** : 372 (1904); *Ann. Soc. Sci. Bruxelles*, **29** : 106 (1905) ; *Das Tierreich*, **41** : 272 (1914).

[1]Berg Mooleyit : Burma.

Genus 18. **Laelius** Ashmead.

Bethylus, (non Latreille 1802 nec Ashmead 1893), FORSTER, *Hym. Stud.*, **2** : 95 (1856).

Laelius, ASHMEAD, *U. S. Nat. Mus. Bull.*, **45** : 50 (1893), [Genotype : *Laelius trogodermatis* Ashmead recorded from *Trogoderma versicolor* Creutz.]. KIEFFER, *Das Tierreich*, **41** : 278 (1914), [Key to species]. MUESEBECK, *Biol. Soc. Washington Proc.*, **52** : 171-176 (1939), [Revision]. MUESEBECK and WALKLEY, *U. S. Dept. Agric.* (*Agric. Mon.*), **2** : 728 (1951), [Synoptic Catalogue of North American species].

Paralaelius, KIEFFER, *Ann. Soc. Sci. Bruxelles*, **29** : 129 (1905), [*Laelius* (*Bethylus*) *pedatus* (Say) parasitises *Anthrenus verbasci* (L) in North America].

voracis Muesebeck.

Laelius voracis, MUESEBECK, *Biol. Soc. Washington Proc.*, **52** : 172 (1939)[1]; *Proc. ent. Soc. Washington*, **42** : 110 (1940). MUESEBECK and WALKLEY, *U. S. Dept. Agric.* (*Agric. Mon.*), **2** : 728 (1951), [Host : Larvae of *Anthrenus vorax* (Waterh). This species has since been recorded from Kanpur, Uttar Pradesh, India][2].

[1]North America.

[2]Kanpur, Uttar Pradesh : India.

Genus 19. **Scaphepyris** Kieffer.

Scaphepyris, KIEFFER, *Ann. Mus. Genova*, **41** : 370 (1904), [Genotype : *Scaphepyris rufus* Kieffer]; *Ann. Soc. Sci. Bruxelles*, **29** : 102 (1905); *Das Tierreich*, **41** : 275 (1914).

rufus KIEFFER.

Scaphepyris rufus, KIEFFER, *Ann. Mus. Genova*, **41** : 370 (1904)[1]; *Das Tierreich*, **41** : 275 (1914).

[1] West Sumatra.

Genus 20. **Ecitopria** Wasmann.

Scleroderma (partim), WESTWOOD, *Trans. ent. Soc. London*, **2** : 169 (1839).

Ecitopria, WASMANN, *Zool. fasc.*, **26** : 55 (1899), [Genotype : *Ecitopria crassicornis* Wasmann]. KIEFFER, *Das Tierreich*, **41** : 285 (1914).

fusca Kieffer.

Ecitopria fusca, KIEFFER, *Ann. Mus. Genova*, **41** : 378 (1904)[1]; *Das Tierreich*, **41** : 286 (1914).

[1] Si-Rambe : Sumatra.

Genus 21. **Laccomerista** Cameron.

Laccomerista, CAMERON, *Entomologist*, **43** : 22 (1910). KIEFFER, *Das Tierreich*, **41** : 286 (1914).

rufuscens Cameron.

Laccomerista rufuscens, CAMERON, *Entomologist*, **43** : 23 (1910)[1]. KIEFFER, *Das Tierreich*, **41** : 287 (1914).

[1] Kuching : Borneo.

Subfamily 2. MESITIINAE.

Mesitiinae, KIEFFER, *Das Tierreich*, **41** : 292 (1914).

Genus 22. **Mesitius** Spinola.

Epyris (partim), H. LUCAS, *Expl. Algerie*, **3** : 321 (1846).

Mesitius, SPINOLA, *Mem. Acc. Torino*, (2) **13** : 72 (1851), [Genotype : *Mesitius ghilianii* Spinola]. KIEFFER, *Das Tierreich*, **41** : 292 (1914); *Ibid*, **44** : 284 (1916), [Key to species]. FOUTS, *Philipp. J. Sci.*, **41** (1) p. 1 (1929), [Key to Oriental species]. PICARD, *Soc. Ent. France, Livre Centen*, 403-414 (1932), [Definition and key to French and Mediterranean species].

Scleroderma (partim), A. COSTA, *Annuario Mus. Zool. Napoli*, **2** : 131 (1862).

Isobrachium, MARSHALL, *Ent. monthly Mag.*, **10** : 222 (1874).

bakeri Fouts.

Mesitius bakeri, FOUTS, *Philipp. J. Sci.*, **41** : 3 (1930)[1].

[1] Luzon : Philippines.

haemorrhoidalis (Magretti).

Mesitius carceli, MAGRETTI, *Ann. Mus. Genova*, (2) **17** : 321 (1897)[1]. — [1]Burma.

Mesitius haemorrhoidalis, KIEFFER, *Das Tierreich*, **41** : 303 (1914).

indicus Kieffer.

Mesitius indicus, KIEFFER, *Bull. Soc. Metz.*, **24** : 39 (1905)[1]; *Das Tierreich* , **41** : 304 (1914). — [1]Bombay : India.

luzonicus KIEFFER.

Mesitius luzonicus, KIEFFER, *Bull. Soc. ent. France*, p. 181 (1914)[1]; *Das Tierreich*, **41** : 304 (1914). — [1]Philippines.

orientalis Fouts.

Mesitius orientalis, FOUTS, *Philipp. J. Sci.*, **41** : 2 (1930)[1]. — [1]Bukidnon, Mindanao : Philippines.

philippinensis Kieffer.

Mesitius philippinensis, KIEFFER, *Philipp. J. Sci.*, **20** : 73 (1922)[1]. — [1]Dapitan, Mindanao : Philippines.

punctaticollis Fouts.

Mesitius punctaticollis, FOUTS, *Philipp. J. Sci.*, **41** : 2 (1930)[1]. — [1]Sandakan : Borneo.

Genus 23. **Rohweria** Fouts.

Rohweria, FOUTS, *Philipp. J. Sci.*, **26** : 515 (1925), [Genotype : *Rohweria metallica* Fouts].

metallica Fouts.

Rohweria metallica, FOUTS, *Philipp. J. Sci.*, **26** : 516 (1925)[1]. — [1]Philippines.

Subfamily 3. EPYRINAE.

Epyrini, KIEFFER, *Das Tierreich*, **41** : 308 (1914).

Genus 24. **Epyris** Westwood.

Epyris, WESTWOOD, *Phil. Mag. Brewster*, (3) **1** (2) p. 129 (1832), [Genotype : *Epyris niger* Westwood]. KIEFFER, *Das Tierreich*, **41** : 308 (1914), [Key to species]. COCKERELL, *Ann. Nat. Hist.*, **5** : 276-277 (1920), [Larvae are parasitic on coleoptera]. KIEFFER, *Philipp. J. Sci.*, **20** : 89-90 (1922), [Key to species]. GELDERN, *Science, New York*, **65** : 302 (1927), [Stinging habits]. BERLAND, *Faune de France*, **19** : 155 (1928), [Key to French species]. MUESEBECK and WALKLEY, *U. S. Dept. Agric. (Agric. Mon.)*, **2** :728 (1951), [Synoptic Catalogue of North American species].

Mesitius, ASHMEAD, *Bull. U. S. Mus.*, **45** : 62 (1893).

Empyris (!), MELANDER and BRUES, *Biol. Bull.*, **5** : 23 (1903).

albipilosus Cameron.
Epyris albipilosus, CAMERON, *Entomologist*, **37** : 307 (1904)[1]. KIEFFER, *Das Tierreich*, **41** : 327 (1914). — [1]Darjeeling : India.

apterus KIEFFER.
Epyris apterus, KIEFFER, *Bull. Soc. ent. France*, p. 60 (1914)[1]; *Das Tierreich*, **41** : 324 (1914). — [1]Philippines.

atavellus Cockerell.
Epyris atavellus, COCKERELL, *Ann. Nat. Hist.*, **5** : 276 (1920)[1]. — [1]Burma.

bidens Kieffer.
Epyris bidens, KIEFFER, *Philipp. J. Sci.*, **20** : 92 (1922)[1]. — [1]Iligan, Mindanao : Philippines.

claripennis Kieffer.
Epyris claripennis, KIEFFER, *Philipp. J. Sci.*, **20** : 94 (1922)[1]. — [1]Laguana; Luzon; Los Banos : Philippines.

coriaceous Muesebeck.
Epyris coriaceous, MUESEBECK, *Rec. Indian Mus.*, **36**: 231-232 (1934)[1]. — [1]Coimbatore, Madras State : India.

despectus KIEFFER.
Epyris despectus, KIEFFER, *Philipp. J. Sci.*, **20** : 93 (1922)[1]. — [1]Luzon : Philippines.

distans Kieffer.
Epyris distans, KIEFFER, *Philipp. J. Sci.*, **20** : 90 (1922)[1]. — [1]Tayabas; Luzon : Philippines.

feai Kieffer.
Epyris feai, KIEFFER, *Ann. Mus. Genova*, **41** : 408 (1904)[1]; *Bull. Soc. Metz.*, **24** : 91 (1905); *Das Tierreich*, **41** : 326 (1914). — [1]Bombay : India.

filiformis Kieffer.
Epyris filiformis, KIEFFER, *Philipp. J. Sci.*, **9** : 288 (1914)[1]. — [1]Philippines.

laticrus Kieffer.
Epyris laticrus, KIEFFER, *Ann. Soc. Sci. Bruxelles*, **35** : 226 (1911)[1]; *Das Tierreich*, **41** : 324 (1914). — [1]Ceylon.

magniceps KIEFFER.
Epyris magniceps, KIEFFER, *Philipp. J. Sci.*, **20** : 98 (1922)[1]. — [1]Puerto Princessa, Palawan : Philippines.

niger Westwood.

Epyris niger, Westwood, *Phil. Mag. Brewster*, (3) **1** : 129 (1832)[1]. Haliday, *Ent. Mag.*, **5** : 519 (1838). Kieffer : Kieffer and Marshall, *Andre, Spec. Hym. Eur.*, **9** : 318, pl. 9, fig. 1 (1906). Kieffer, *Das Tierreich*, **41** : 314 (1914)[2].

Epyris nigra, Dalla Torre, *Cat. Hym.*, 5 : 553 (1898).

[1] Egypt.
[2] Philippines.

obliques Kieffer.

Epyris obliques, Kieffer, *Philipp. J. Sci.*, **20** : 91 (1922)[1].

[1] Mindanao; Butuan : Philippines.

parvidens Kieffer.

Epyris parvidens, Kieffer, *Philipp. J. Sci.*, **20** : 99 (1922)[1].

[1] Laguna, Luzon : Philippines.

philippinensis Kieffer.

Epyris philippinensis, Kieffer, *Insecta*, **3** : 258 (1913)[1]; *Das Tierreich*, **41** :324 (1914).

[1] Philippines.

pilosipes Kieffer.

Epyris pilosipes, Kieffer, *Das Tierreich*, **41** : 309 (1914)[1].

[1] Portugese Guinea.

politiceps Muesebeck.

Epyris politiceps, Muesebeck, *Rec. Indian Mus.*, **36** : 230-231 (1934)[1].

[1] Mysore : India.

psilomma Kieffer.

Epyris psilomma, Kieffer, *Philipp. J. Sci.*, **20** : 96 (1922)[1].

[1] Puerto Princessa, Palawan : Philippines.

pusillus Kieffer.

Epyris pusillus, Kieffer, *Philipp. J. Sci.*, **20** : 94 (1922)[1].

[1] Mindanao; Butuan: Philippines.

quadratus Kieffer.

Epyris quadratus, Kieffer, *Philipp. J. Sci.*, **20** : 97 (1922)[1].

[1] Butuan; Mindanao : Philippines.

quaesitor Kieffer.

Epyris quaesitor, Kieffer, *Philipp. J. Sci.*, **20** : 95 (1922)[1].

[1] Luzon; Laguana : Philippines.

rejectus Kieffer.

Epyris rejectus, Kieffer, *Philipp. J. Sci.*, **20** : 94 (1922)[1].

[1] Mount Màquiling, Luzon : Philippines.

ruficollis Ashmead.

Epyris ruficollis, Ashmead, *Indian Mus.*, **5** (3) p. 171 (1903)[1].

[1] Quetta, Baluchistan : Pakistan.

ruficornis (Magretti).

Pristocera ruficornis, MAGRETTI, *Ann. Mus. Genova*, **37** : 317 (1897)[1].

Epyris ruficornis, KIEFFER, *Das Tierreich*, **41** : 326 (1914).

[1]Carin Cheba : Burma.

secondus Brues.

Epyris analis (Cresson 1872) : KIEFFER, *Ann. Soc. Sci. Bruxelles*, **29** : 111 (1905).

Epyris secondus, BRUES, *Bull. Wisconsin Soc.*, (2) **4** : 143 (1906)[1]. KIEFFER, *Das Tierreich*, **41** : 326 (1914).

[1]Mahe : India.

striatus Kieffer.

Epyris striatus, KIEFFER, *Ann. Mus. Genova*, **41** : 406 (1904)[1]; *Das Tierreich*, **41** : 325 (1914).

[1]Burma.

subramosus Kieffer.

Epyris subramosus, KIEFFER, *Philipp. J. Sci.*, **20** : 100 (1922)[1].

[1]Puerto Princessa, Palawan : Philippines.

tridens Kieffer.

Epyris tridens, KIEFFER, *Philipp. J. Sci.*, **20** : 92 (1922)[1].

[1]Laguana ; Luzon : Philippines.

troglodytes Kieffer.

Epyris troglodytes, KIEFFER, *Philipp. J. Sci.*, **20** : 93 (1922)[1].

[1]Los Banos; Laguana; Luzon : Philippines.

unicarina Kieffer.

Epyris unicarina , KIEFFER, *Philipp. J. Sci.*, **20** : 99 (1922)[1].

[1]Butuan; Mindanao : Philippines.

valens Kieffer.

Epyris valens, KIEFFER, *Ann. Soc. Sci. Bruxelles*, **35** : 227 (1911)[1]; *Das Tierreich*, **41** : 325 (1914).

[1]Punduloya : Ceylon.

Genus 25. **Rhabdepyris** Kieffer.

Epyris (Westwood 1832), ASHMEAD, *Bull. U. S. Mus.*, **45** : 59 (1893).

Rhabdepyris, KIEFFER, *Bull. Soc. Metz.*, (2) **11** : 32 (1904), [Genotype : *Rhabdepyris myrmecophilus* Kieffer]. Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 375 (1906). KIEFFER, *Das Tierreich*, **41** : 346 (1914), [Key to subgenera]. TURNER and WATERSON, *Rpt. Grain Pests (War) Com. [Gt. Brit.]*, **9** : 29 (1921), [*Rhabdepyris zeae* Turner and Waterson : Cosmopolitan in distribution. Hosts : Grain pests : *Sitophilus oryza* (L.); *Tribolium castaneum* (Hbst.); *Tribolium confusum* Duval; *Laemophloeus ferrugineus* (Steph)]. KIEFFER, *Philipp. J. Sci.*, **20** : 88 (1922). Muesebeck and Walkley, *U. S. Dept. Agric.* (*Agric. Mon.*), **2** : 729-730 (1951), [Synoptic Catalogue of North American species].

Tricholepyris, Kieffer, *Andre, Spec. Hym. Eur.*, **9** : 376 (1906), [Proposed as a subgenus of *Rhabdepyris*—Type : *Rhabdepyris pallidipennis* Kieffer].

defectus Kieffer.

Rhabdepyris defectus, Kieffer, *Philipp. J. Sci.*, **20** : 88 (1922)[1].

[1] Mount Maquiling, Laguana, Luzon : Philippines.

exaratus Kieffer.

Rhabdepyris exaratus, Kieffer, *Insecta*, **3** : 317 (1914)[1].

[1] Philippines.

foveatus (Cameron).

Epyris (?) *foveatus*, Cameron, *Spolia Zeyl*, **3** : 71 (1905)[1].

Rhabdepyris (*R.*) *foveatus*, Kieffer, *Das Tierreich*, **41** : 353 (1914).

[1] Peradenia : Ceylon.

fuscinervis (Cameron).

Epyris fuscinervis, Cameron, *Mem. Manchest. Soc.*, **43** (3) p. 50 (1899)[1].

Rhabdepyris fuscinervis, Kieffer, *Andre, Spec. Hym. Eur.*, **9** : 575 (1906).

Rhabdepyris (*R.*) *fuscinervis*, Kieffer, *Das Tierreich*, **41** : 353 (1914)[1].

[1] Barrackpore, Bengal India.

longiceps Kieffer.

Rhabdepyris longiceps, Kieffer, *Insecta*, **3** : 318 (1914)[1].

[1] Philippines.

luzonicus Kieffer.

Rhabdepyris luzonicus, Kieffer, *Boll. Laborat. Zool. Portici*, **7** : 189 (1913)[1]; *Philipp. J. Sci.*, **20** : 88 (1922).

Rhabdepyris (*R.*) *luzonicus*, Kieffer, *Das Tierreich*, **41** : 354 (1914).

[1] Laguana, Luzon : Philippines.

Genus 26. **Parepyris** Kieffer.

Epyris (partim), Kieffer, *Ann. Mus. Genova*, **41** : 398 (1904).

Parepyris, Brenthes, *Ann. Mus. Buenos Aires*, **24** : 87 (1913), [Genotype : *Parepyris sylvanidis* Brenthes]. Kieffer, *Boll. Laborat. Zool. Portici*, **7** : 108 (1913); *Das Tierreich*, **41** : 410

(1914), [Key to species] ; *Philipp. J. Sci.*, **20** : 82 (1922), [Key to Oriental species].

acutidens Kieffer.

Parepyris acutidens, KIEFFER, *Philipp. J. Sci.*, **20** : 83 (1922)[1].

[1]Butuan, Mindanao : Philippines.

pleuralis Kieffer.

Parepyris pleuralis, KIEFFER, *Philipp. J. Sci.*, **20** : 84 (1922)[1].

[1]Tacloban, Leyte : Philippines.

trunctatidens Kieffer.

Parepyris trunctatidens, KIEFFER, *Philipp. J. Sci.*, **20** : 82 (1922)[1].

[1]Cuernos Mountain, Negros; Butuan, Mindanao : Philippines.

Genus 27. **Cladobethylus** Kieffer.

Cladobethylus, KIEFFER, *Philipp. J. Sci.*, **20** : 67-71 (1922), [Genotype : *Cladobethylus cruciger* Kieffer], [Key to species].

cruciger Kieffer.

Cladobethylus cruciger, KIEFFER, *Philipp. J. Sci.*, **20**: 69-70 (1922)[1].

[1]Butuan, Mindanao : Philippines.

cveruleus Kieffer.

Cladobethylus cveruleus, KIEFFER, *Philipp. J. Sci.*, **20** : 71 (1922)[1].

[1]Butuan, Mindanao : Philippines.

myrmecophilus Kieffer.

Cladobethylus myremecophilus, KIEFFER, *Philipp. J. Sci.*, **20** : 68-69 (1922)[1].

[1]Butuan; Mindanao : Philippines.

Genus 28. **Isobrachium** A. Forster.

Omalus (partim), NEES, *Hym. Monogr.*, **2** : 392 (1834).

Bethylus, A. FORSTER, *Verh. ver. Rheinlande*, **8** : 13 (1851).

Isobrachium, (Ashmead 1893) : FORSTER, *Hym. Stud.*, **2** : 96 (1856), [Genotype : *Isobrachium nigricorne* Nees]. Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 305 (1906). KIEFFER, *Das Tierreich*, **41** : 367-369 (1914); *Philipp. J. Sci.* ,**20** : 71 (1922).

Epyris (partim), CAMERON, *J. Bombay Soc.*, **17** : 228 (1906).

bipunctatum Kieffer ?.

Isobrachium bipunctatum, KIEFFER, *Philipp. J. Sci.*, **20** : 71 (1922)[1].

[1]Butuan, Mindanao : Philippines.

luzonicum Kieffer.

Isobrachium luzonicum, KIEFFER, *Philipp. J. Sci.*,

[1]Mount Maquiling,

20 : 72 (1922)[1].

Laguana, Luzon : Philippines.

rugicolle (Cameron).

Epyris rugicolle, CAMERON, *J. Bombay Soc.*, **17** : 288 (1906)[1].

[1]Quetta, Baluchistan : Pakistan.

Isobrachium rugicolle, KIEFFER, *Das Tierreich*, **41** : 369 (1914).

Genus 29. **Neurepyris** Kieffer.

Epyris (partim), ASHMEAD, *Proc. U. S. Mus.*, **29** : 109 (1905).

Neurepyris, Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 251 (1905), [Genotype : *Neurepyris rufiventer* Kieffer]. KIEFFER, *Gen. Ins.*, **76** : 32 (1908); *Das Tierreich*, **41** : 370 (1914), [Key to species].

tagala (Ashmead).

Epyris tagala, ASHMEAD, *Proc. U. S. Mus.*, **29** : 109 (1905)[1].

[1]Manila, Luzon : Philippines.

Rhabdepyris tagala, KIEFFER, *Gens. In.*, **76** : 32 (1908).

Neurepyris tagala, KIEFFER, *Das Tierreich*, **41** : 371 (1914).

Genus 30. **Holepyris** Kieffer.

Epyris (partim), MAGRETTI, *Ann. Mus. Genova*, (2) **17** : 317 (1897).

Holepyris, KIEFFER, *Ann. Mus. Genova*, **41** : 390 (1904), [Genotype : *Holepyris africanus* Kieffer] ; *Ann. Soc. Sci. Bruxelles*, **29** : 121 (1905); *Das Tierreich*, **41** : 371 (1914); *Philipp. J. Sci.*, **20** : 85 (1922). MUESEBECK and WALKLEY, *U. S. Dept. Agric.* (*Agric. Mon.*), **2** :730 (1951), [Synoptic Catalogue of American species].

Rysepyris, KIEFFER, *Andre, Spec. Hym. Eur.*, **9** : 341 (1906).

Isobrachium, CAMERON, *Entomologist*, **43** : 175 (1910).

andrei Kieffer.

Holepyris andrei, KIEFFER, *Ann. Soc. Sci., Bruxelles*, **29**: 122 (1905)[1]; *Das Tierreich*, **41** : 384 (1914).

[1]Mahe : India.

dubiosus Kieffer ?.

Holepyris dubiosus, KIEFFER, *Philipp. J. Sci.*, **20** : 86 (1922)[1].

[1] Puerto Princessa, Palawan : Philippines.

kuchingensis (Cameron).

Isobrachium kuchingense, CAMERON, *Entomologist*, **43** : 175 (1910)[1].

[1]Kuching : Borneo.

Holepyris kuchingensis, KIEFFER, *Das Tierreich*, **41** : 384 (1914).

minimus (Magretti).

Epyris minimus, MAGRETTI, *Ann. Mus. Genova*, (2) **17** : 320, fig. 10 (1897)[1].

[1]Rangoon : Burma.

Holepyris minimus, KIEFFER, *Gen. Ins.*, **76** : 30 (1908); *Das Tierreich*, **41** : 383 (1914).

parvus (Magretti).

Epyris parvus, MAGRETTI, *Ann. Mus. Genova*, (2) **17** : 319 (1897)[1].

[1]Rangoon : Burma.

Holepyris parvus, KIEFFER, *Gen. Ins.*, **76** : 30 (1908); *Das Tierreich*, **41** : 383 (1914).

philippinensis Kieffer.

Holepyris philippinensis, KIEFFER, *Philipp. J. Sci.*, **20** : 85 (1922)[1].

[1]Butuan, Mindanao, Luzon : Philippines.

Genus 31. **Apenesia** Westwood.

Scleroderma, FRED SMITH, *Proc. Linn. Soc. London*, **7** : 27 (1863).

Apenesia, WESTWOOD, *Thesaur. ent. Oxon.*, p. 170 (1874), [Genotype : *Apenesia sjostedti* (Tullg.)]; *Trans. ent. Soc. London*, p. 130 (1881). KIEFFER, *Ann. Mus. Genova*, **41** : 366-367 (1904); *Das Tierreich*, **41** : 391 (1914), [Key to species].

Aeluroides, TULLGREN, *Ark. Zool.*, **1** : 428 (1904).

unicolor Kieffer.

Apenesia unicolor, KIEFFER, *Ann. Mus. Genova*, **41** : 360 (1904)[1]; *Das Tierreich*, **41** :394 (1914)[1]; *Philipp. J. Sci.*, **20** : 80 (1922).[2]

[1]Fernando Island : West Africa.
[2]Puerto Princessa, Palawan: Philippines.

Genus 32. **Misepyris** Kieffer.

Holepyris (partim), KIEFFER, *Berlin ent. Z.*, **50** : 247 (1906).

Rhabdepyris (partim), KIEFFER, *Insecta*, **3** : 317 (1913).

Misepyris, KIEFFER, *Boll. Laborat. Zool. Portici*, **7** : 108 (1913), [Genotype : *Misepyris remotus* (Kieffer)]; *Das Tierreich*, **41** : 398 (1914). FOUTS, *Philipp. J. Sci.*, **41** : 3 (1929), [Key to Oriental species].

exaratus (Kieffer).

Rhabdepyris exaratus, KIEFFER, *Insecta*, **3** : 317 (1913)[1].

[1]Los Banos : Philippines.

Misepyris exaratus, KIEFFER, *Das Tierreich*, **41** : 399 (1914).

flavipes Fouts.

Misepyris flavipes, FOUTS, *Philipp. J. Sci.*, **41** : 3 (1929)[1].

[1]Mount Maquiling, Luzon : Philippines.

longiceps (Kieffer).

Rhabdepyris longiceps, KIEFFER, *Insecta*, **3** : 318 (1913)[1].

[1]Los Banos : Philippines.

Misepyris longiceps, KIEFFER, *Das Tierreich*, **41** : 399 (1914).

luzonicus Fouts.

Misepyris luzonicus, FOUTS, *Philipp. J. Sci.*, **41** : 5 (1929)[1].

[1]Mount Maquiling, Luzon : Philippines.

mindanaensis Fouts.

Misepyris mindanaensis, FOUTS, *Philipp. J. Sci.*, **41** : 4 (1929)[1].

[1]Surigo, Butuan, Mindanao : Philippines.

politus Fouts.

Misepyris politus, FOUTS, *Philipp. J. Sci.*, **41** : 4 (1929)[1].

[1]Surigo, Mindanao : Philippines.

Genus 33. **Acanthepyris** Kieffer.

Epyris (partim), KIEFFER, *Ann. Mus. Genova*, **41** : 398 (1904).

Epyris sub. gen. *Acanthepyris*, KIEFFER, *Ergeb. Zentr. Afr. Exp.*, **3** (2) p. 13 (1910), [East African species var. *vagus* of sub. gen. *Acanthepyris*].

Trachepyris (partim), KIEFFER, *Ann. Soc. Sci. Bruxelles*, **35** : 230 (1911).

Acanthepyris, KIEFFER, *Das Tierreich*, **41** : 401 (1914), [Genotype : *Acanthepyris hilderbrandti* Kieffer].

haemorrhoidalis (Kieffer).

Trachepyris haemorrhoidalis, KIEFFER, *Ann. Soc. Sci. Bruxellus*, **35** : 230 (1911)[1].

[1]Karachi, Sind : Pakistan.

Acanthepyris haemorrhoidalis, KIEFFER, *Das Tierreich*, **41** : 404 (1914).

Genus 34. **Homoglenus** Kieffer.

Homoglenus, KIEFFER, *Ann. Mus. Genova*, **41** : 388 (1904), [Genotype : *Homoglenus punctatus* Kieffer]. Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 370 (1906). KIEFFER, *Das Tierreich*, **41** : 408 (1914).

Epyris (partim), KIEFFER, *Bull. Soc. Metz.*, **24** : 90 (1905).

indicus (Kieffer).

Epyris indicus, KIEFFER, *Bull. Soc. Metz.*, **24** : 91 (1905)[1].

Homoglenus indicus, KIEFFER, *Das Tierreich*, **41** : 409 (1914).

[1]Matheran, Bombay : India.

montanus (Kieffer).

Epyris montanus, KIEFFER, *Bull. Soc. Metz.*, **24** : 90 (1905)[1].

Homoglenus montanus, KIEFFER, *Das Tierreich*, **41** : 410 (1914).

[1]Matheran, Bombay : India.

Genus 35. **Chlorepyris** Kieffer.

Epyris (partim), KIEFFER, *Ann. Soc. Sci. Bruxelles*, **35** : 223 (1911).

Chlorepyris, KIEFFER, *Boll. Laborat. Zool. Portici*, **7** : 108 (1913), [Genotype : *Chlorepyris semiviridis* Kieffer]; *Das Tierreich*, **41** : 412 (1914), [Key to species]; *Philipp. J. Sci.*, **20** : 76-77 (1922). MUESEBECK and WALKLEY, *U. S. Dept. Agric.* (*Agric. Mon.*), **2** : 730 (1951), [Synoptic Catalogue of North American Species].

conjunctus (Kieffer).

Epyris conjunctus, KIEFFER, *Bull. Soc. Metz.*, **24** : 92 (1905)[1].

Chlorepyris conjunctus, KIEFFER, *Das Tierreich*, **41** : 413 (1914).

[1]Bombay : India.

flavipennis Kieffer.

Chlorepyris flavipennis, KIEFFER, *Bull. Soc. ent. France*, p. 60 (1914)[1]; *Das Tierreich*, **41** : 413 (1914).

[1]Manila, Luzon : Philippines.

raptor Kieffer.

Chlorepyris raptor, KIEFFER, *Philipp. J. Sci.*, **20** : 77-78 (1922)[1].

[1]Cuernos Mountain, Negros : Philippines.

raripilus Kieffer.

Chlorepyris raripilus, KIEFFER, *Philipp. J. Sci.*, **20** : 76-77 (1922)[1].

[1]Butuan, Mindanao : Philippines.

similis Bridwell.

Chlorepyris similis, BRIDWELL, *Proc. Hawaii ent. Soc.*, **4** : 35 (1919)[1].

[1]Los Banos; Luzon : Philippines.

unidens Kieffer.

Chlorepyris unidens, KIEFFER, *Philipp. J. Sci.*, **20** : 78-79 (1922)[1].

[1]Mount Banahao, Tayabas, Luzon : Philippines.

Genus 36. **Melanepyris** Kieffer.

Epyris (partim.), Kieffer : ALLUAUD and JEANNEL, *Voy. Afr. Or. Hym.*, **1** : 6 (1913).

Melanepyris, KIEFFER, *Das Tierreich*, **41** : 418 (1914), [Genotype : *Melanepyris iraicola* (Kieffer)]; *Boll. Laborat. Zool. Portici*, **7** : 108 (1913); *Philipp. J. Sci.*, **20** : 84 (1922).

asiaticus Kieffer.

Melanepyris asiaticus, KIEFFER, *Philipp. J. Sci.*, **20** : 84 (1922)[1].

[1] Dapitan, Mindanao : Philippines.

Genus 37. **Lytepyris** Kieffer.

Pristocera (partim), MAGRETTI, *Ann. Mus. Genova*, (2) **1** : 533 (1884).

Epyris (partim), MAGRETTI, *Ann. Mus. Genova*, **17** : 319 (1897).

Trachepyris (partim), Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 414 (1906).

Lytepyris, KIEFFER, *Boll. Laborat. Zool. Portici* **7** : 108 (1913), [Genotype : *Lytepyris biscrensis* (Kieffer)]; *Das Tierreich*, **41** : 416-417 (1914).

afer (Magretti).

Lytepyris afra, MAGRETTI, *Ann. Mus. Genova*, (2) **1** : 533 (1884).

Epyris afer, MAGRETTI, *Ann. Mus. Genova*, **17** : 319 (1897).

Lytepyris afer, KIEFFER, *Boll. Laborat. Zool. Portici*, **7** : 108 (1913); *Das Tierreich*, **41** : 416-417 (1914)[1], [Host : On flowers of *Kanahia delilei* DC. and *Calotropis procera* L.].

[1] Bhamo; Palon : Burma & Sudan.

Genus 38. **Xenepyris** Kieffer.

Xenepyris, KIEFFER, *Insecta*, **3** : 259 (1913), [Genotype : *Xenepyris compressicornis* Kieffer]; *Das Tierreich*, **41** : 429 (1914).

compressicornis Kieffer.

Xenepyris compressicornis, KIEFFER, *Insecta*, **3** : 259, fig. 3 (1913)[1]; *Das Tierreich*, **41** : 429 (1914).

[1] Philippines.

exaratus Kieffer.

Xenepyris exaratus, KIEFFER, *Philipp. J. Sci.*, **20** : 87 (1922)[1].

[1] Mount Maquiling, Laguna; Luzon : Philippines.

Genus 39. **Calyozina** Enderlein.

Calyozina, ENDERLEIN, *Ent. Mitt.*, **1** : 263 (1912), [Genotype : *Calyozina ramicornis* Enderlein]. KIEFFER, *Das Tierreich*, **41** : 429 (1914).

ramicornis Enderlein.

Calyozina ramicornis, ENDERLEIN, *Ent. Mitt.*, **1** : 263 (1912)[1]. KIEFFER, *Das Tierreich*, **41** : 429 (1914). — [1]Formosa.

Genus 40. **Calyoza** Westwood.

Calyoza, Westwood : HOPE, *Trans. ent. Soc. London*, **2** : 56 (1837), [Genotype : *Calyoza staphylinoides* Westwood]. KIEFFER, *Das Tierreich*, **41** : 431 (1914), [Key to species]; *Philipp. J. Sci.*, **20** : 79 (1922).

nigra Kieffer.

Calyoza nigra, KIEFFER, *Philipp. J. Sci.*, **20** : 79 (1922)[1]. — [1]Puerto Princessa, Palawan : Philippines.

Genus 41. **Calozella** Enderlein.

Calozella, ENDERLEIN, *Zool. Anz.*, **51** : 23-24 (1920), [Genotype : *Calozella flavipennis* Enderlein].

flavipennis Enderlein.

Calozella flavipennis, ENDERLEIN, *Zool. Anz.*, **51**: 24 (1920)[1]. — [1]Sumatra.

sauteri Enderlein.

Calozella sauteri, ENDERLEIN, *Zool. Anz.*, **51** : 25 (1920)[1]. — [1]Formosa.

Genus 42. **Paracalyoza** Cameron.

Paracalyoza, CAMERON, *D. ent. Z.*, p. 377 (1909), [Genotype : *Paracalyoza hirtipennis* Cameron]. KIEFFER, *Das Tierreich*, **41** : 430 (1914).

hirtipennis Cameron.

Paracalyoza hirtipennis, CAMERON, *D. ent. Z.*, p. 377 (1909)[1]. KIEFFER, *Das Tierreich*, **41** : 430 (1914). — [1]Kuching : Borneo.

Genus 43. **Pristobethylus** Kieffer.

Epyris (partim), WESTWOOD, *Thesaur. ent. Oxon.*, p. 161 (1874).

Pristobethylus, Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 248 (1905), [Genotype : *Pristobethylus serricollis* Kieffer]; *Das Tierreich*, **41** : 448 (1914).

indicus Muesebeck.

Pristobethylus indicus, MUESEBECK, *Rec. Indian Mus.*, **36** : 223-225 (1934)[1]. — [1]Chaughat, South Malabar : India.

Genus 44. **Disepyris** Kieffer.

Disepyris, KIEFFER, *Ann. Soc. Sci. Bruxelles*, **29** : 115 (1905), [Genotype : *Disepyris rufipes* Kieffer]; *Das Tierreich*, **41** : 447 (1914).

pallidinervis Cameron.

Disepyris pallidinervis, CAMERON, *J. Bombay Soc.*, **17** : 578 (1907)[1]. KIEFFER, *Das Tierreich*, **41** : 448 (1914).

[1]Deesa, Bombay : India.

rufipes KIEFFER.

Disepyris rufipes, KIEFFER, *Ann. Soc. Sci. Bruxelles*, **29**:115 (1905)[1]; *Das Tierreich*, **41**:448 (1914).

[1]Mahe, Malabar : India.

Genus 45. **Foenobethylus** Kieffer.

Foenobethylus, KIEFFER, *Insecta*, **3** : 258 (1913), [Genotype : *Foenobethylus gracilis* Kieffer]; *Das Tierreich*, **41** : 450 (1914).

gracilis Kieffer.

Foenobethylus gracilis, KIEFFER, *Insecta*, **3** : 298 (1913)[1]; *Das Tierreich*, **41** : 450 (1914).

[1]Los Banos : Philippines.

Subfamily 4. PRISTOCERINAE.

Pristocerinae, KIEFFER, *Das Tierreich*, **41** : 451 (1914).

Genus 46. **Pristocera** Klug.

Bethylus (partim), FABRICIOUS, *Syst. piez.*, p. 237 (1804).

Pristocera, KLUG, *Mag. Ges. Fr. Berlin*, **2** : 49 (1808), [Genotype : *Pristocera depressa* (Fabricious)]. Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 287 (1905). BRUES, *Wis. Nat. Hist. Soc. Bull.*, **4** : 143 (1906). KIEFFER, *Das Tierreich*, **41** : 453-455 (1914), [Key to world species]. HAYES, *Proc. ent. Soc. Washington*, **29** (1) p. 20-22 (1927), [*Aeolus elegans* (Fabr.) recorded as another host of *Pristocera armifera* (Say) from Kansas]. MUESEBECK and WALKLEY, *U. S. Dept. Agric.* (*Agric. Mon.*), **2** : 731 (1951), [Synoptic Catalogue of North American species].

Epyris (partim), CRESSON, *Trans. Amer. ent. Soc.*, **4** : 193 (1872).

antennata Magretti.

Pristocera antennata, MAGRETTI, *Ann. Mus. Genova*, (2) **17** : 315 (1897)[1]. KIEFFER, *Das Tierreich*, **41** : 459 (1914).

[1]Burma.

areolata Muesebeck.

Pristocera areolata, MUESEBECK, *Rec. Indian Mus.*, **36** : 229 (1934)[1].

[1]Coimbatore, Madras State : India.

carina Magretti.

Pristocera carina, MAGRETTI, *Ann. Mus. Genova*, (2) **17** : 316 (1897)[1]. KIEFFER, *Das Tierreich*, **41** : 459 (1914).

[1]Burma.

drewseni Westwood.

Pristocera drewseni, WESTWOOD, *Thesaur. ent. Oxon.*, p. 164, pl. 31, fig. 7 (1874)[1]. KIEFFER, *Das Tierreich*, **41** : 459 (1914).

[1]Ceylon.

eironeformis Turner.

Pristocera eironeformis, TURNER, *Ann. Nat. Hist.*, **14** : 245 (1914)[1].

[1]India.

formosana Miwa and Sonan.

Pristocera formosana, MIWA and SONAN, *Trans. n. H. Soc. Formosa*, **25**: 91 (1935)[1], [In Japanese].

[1]Formosa.

orientalis (Cameron).

Epyris orientalis, CAMERON, *Mem. Manchest. Soc.*, (4) **1** : 169 (1888)[1].

Pristocera orientalis, KIEFFER, *Ann. Soc. Sci. Bruxelles*, **29** : 111 (1905); *Das Tierreich*, **41** : 460 (1914).

[1]Barrackpore, Bengal: India.

puncticeps Fouts.

Pristocera puncticeps, FOUTS, *Philipp. J. Sci.*, **41** : 5 (1930)[1].

[1]Dapitan, Mindanao: Philippines.

rufa Kieffer.

Pristocera rufa, KIEFFER, *Ann. Soc. Sci. Bruxelles*, **29** : 126 (1905)[1]; *Das Tierreich*, **41** : 460 (1914).

[1](Ostindien) : India.

sinhalensis Turner.

Pristocera sinhalensis, TURNER, *Ann. Mag. Nat. Hist.*, (10) **1** : 145 (1928)[1].

[1]Peradenia : Ceylon.

Genus 47. **Pseudisobrachium** Kieffer.

Isobrachium (err. non. A. Forster 1856), ASHMEAD, *Ent. Amer.*, **3** : 76 (1887) ; *Bull. U. S. Mus.*, **45** : 38 (1893).

Pseudisobrachium, KIEFFER, *Ann. Mus. Genova*, **41** : 368 (1904), [Genotype : *Pseudisobrachium laticeps* Kieffer] ; *Das Tierreich*, **41** : 472-473 (1914), [Key to species]. FOUTS, *Proc. ent. Soc. Washington*, **30** (7) pp. 121-132 (1928), [Key to North American Species].

Monepyris, KIEFFER, *Ann. Soc. Sci. Bruxelles*, **29** : 101-124 (1905).

philippinaram Kieffer.

Pseudisobrachium philippinarum, KIEFFER, *Philipp. J. Sci.*, **20** : 80 (1922)[1].

[1]Butuan, Mindanao : Philippines.

unidens Kieffer.

Pseudisobrachium unidens, KIEFFER, *Philipp. J. Sci.*, **20** : 81 (1922)[1].

[1]Mount Maquiling, Laguana, Luzon : Philippines.

Genus 48. **Propristocera** Kieffer.

Propristocera, Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 247 (1905), [Genotype : *Propristocera interrupta* Kieffer]. KIEFFER, *Bull. Soc. Metz.*, **24** : 98 (1905); Das Tierreich **41** : 484 (1914), [Key to species].

Pseudisobrachium, KIEFFER, *Berlin ent. Z.*, **51** : 289 (1907).

Pristocera (partim) , KIEFFER, *Ann. Soc. Sci. Bruxelles*, **35** : 215 (1911).

interrupta Kieffer.

Propristocera interrupta, KIEFFER, *Bull. Soc. Metz.*, **24** : 98 (1905)[1]; *Das Tierreich*, **41** : 484 (1914).

[1]Pattipola : Ceylon.

levicollis Kieffer.

Propristocera levicollis, KIEFFER, *Bull. Soc. Metz.*, **24**: 100 (1905)[1]; *Das Tierreich*, **41**: 485 (1914).

[1]Matheran, Bombay : India.

pallidimanus (Kieffer).

Pristocera pallidimanus, KIEFFER, *Trans. Linn. Soc. London*, (2) **15** : 48 (1912)[1].

Propristocera pallidimanus, KIEFFER, *Das Tierreich*, **41** : 486 (1914).

[1]Mahe, Seychelles Islands.

percurrens Kieffer.

Propristocera percurrens, KIEFFER, *Bull. Soc. Metz.*, **24** : 99 (1905)[1]; *Das Tierreich*, **41**: 485 (1914).

[1]Matheran, Bombay : India.

remota (Kieffer).

Pristocera remota, KIEFFER, *Trans. Linn. Soc. London*, (2) **15** : 43 (1912)[1].

Propristocera remota, KIEFFER, *Das Tierreich*, **41** : 485 (1914).

[1]Mahe, Seychelles Islands.

Genus 49. **Cleistepyris** Kieffer.

Epyris (partim), WESTWOOD, *Thesaur. ent. Oxon.*, p. 158 (1874).

Rhabdepyris (partim), KIEFFER, *Gen. Ins.*, **76** : 32 (1908).

Cleistepyris, KIEFFER, *Ann. Soc. Ent. France*, **79** : 48 (1910), [Genotype : *Cleistepyris punctatus*

Kieffer]; *Das Tierreich*, **41** : 490 (1914); *Philipp. J. Sci*, **20** : 73-74 (1922), [Key to species].

consobrinus Kieffer.

Cleistepyris consobrinus, KIEFFER, *Philipp. J. Sci.*, **20** : 75 (1922)[1].

[1]Mount Banahao, Luzon ; Tayabas : Philippines.

intricatus Kieffer.

Cleistepyris intricatus, KIEFFER, *Philipp. J. Sci.*, **20** : 74 (1922)[1].

[1]Mount Maquiling., Luzon; Laguana : Philippines.

lathrobioides (Westwood).

Cleistepyris lathrobioides, WESTWOOD, *Thesaur. ent. Oxon.*, p. 158, pl. 29, fig. 7 (1874)[1].

Cleistepyris latherobiodes, KIEFFER, *Das Tierreich*, **41** : 492 (1914).

[1]Ceylon.

minimus Kieffer.

Cleistepyris minimus, KIEFFER, *Insecta*, **3** : 257 (1913)[1]; *Das Tierreich*, **41** : 492 (1914).

Cleistepyris clypeatus, KIEFFER, *Philipp. J. Sci.*, **20** : 75-76 (1922)[1], [*clypeatus* is only a variety of *minimus*].

[1]Dapitan, Butuan, Los Banos; Mindānao, Palawan : Philippines.

minor Kieffer.

Cleistepyris minor, KIEFFER, *Insecta*, **3** : 256 (1913)[1]; *Das Tierreich*, **41** : 491 (1914); *Philipp. J. Sci.*, **20** : 76 (1922).[2]

[1]Luzon : Philippines. [2]Malinao , Butuan ; Mount Banahao, Tayabas, Paete; Mount Maquiling, Laguana, Los Banos, Luzon : Philippines.

philippinensis Kieffer.

Cleistepyris philippinensis, KIEFFER, *Insecta*, **3** : 254, pl. 1 (1913)[1]; *Das Tierreich*, **41** : 491 (1914).

[1]Laguna, Los Banos, Mount Maquiling, Tayabas, Luzon : Philippines.

xanthopterus Kieffer.

Cleistepyris xanthopterus, KIEFFER, *Philipp. J. Sci.*, **20** : 74 (1922)[1].

[1]Mount Banahao, Tayabas, Luzon : Philippines.

Genus 50. **Dissomphalus** Ashmead.

Dissomphalus, ASHMEAD, *Bull. U. S. Mus.*, **45** : 41 (1893), [Genotype : *Dissomphalus xanthopus* Ashmead]. KIEFFER, *Das Tierreich*, **41**: 495 (1914), [Key to species].

brevinervis Kieffer.

Dissomphalus brevinervis, KIEFFER, *Ann. Mus. Genova*, **41** : 371 (1904)[1]; *Das Tierreich*, **41** : 497 (1914).

[1]Sumatra.

tibialis Ashmead.

Dissomphalus tibialis, ASHMEAD, *Proc. U. S. Mus.*, **28** : 134 (1904)[1]. KIEFFER, *Das Tierreich*, **41** : 497 (1914).

[1]Manila, Luzon : Philippines.

Genus 51. **Leptepyris** Kieffer.

Leptepyris, KIEFFER, *Bull. Soc. ent. France*, p. 180 (1914), [Genotype : *Leptepyris filiformis* Kieffer]; *Das Tierreich*, **41** : 505 (1914).

filiformis Kieffer.

Leptepyris filiformis, KIEFFER, *Bull. Soc. ent. France*, p. 180 (1914)[1]; *Das Tierreich*, **41** : 505 (1914).

[1]Luzon : Philippines.

Subfamily 5. BETHYLINAE.

Bethylinae, KIEFFER, *Das Tierreich*, **41** : 507 (1914).

Genus 52. **Bethylus** Latreille.

Tiphia, PANZER, *Faun. Ins. Germ.*, **7** : 77, pl. 14 (1801).

Bethylus, LATREILLE, *Hist. Crust. Ins.*, **3** : 315 (1802), [Genotype : *Bethylus fuscicornis* (Jurine), Latreille placed *Bethylus hemipterus* Latreille as Genotype]; *Ibid*, **13** : 228 (1805). Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 267 (1905). KIEFFER, *Das Tierreich*, **41** : 507 (1914), [Key to species].

Ceraphron, PANZER, *Krit. Revis.*, **2** : 135 (1806 ?).

Omalus, JURINE, *Nouv. Meth. Hym.*, p. 300 (1807).

Dryinus, LAMARK, *Hist. An. s. Vert.*, **4** : 131 (1817).

Rhagigaster, WESTWOOD, *Arcan. ent.*, **2** : 106 (1844).

Perisemus, FORSTER, *Hym. Stud.*, **2** : 95-96 (1856).

Episemus, THOMSON, *Ofv. Ak. Forh.*, **18** : 452 (1862).

Epyris, PROVANCHER, *Addit. Hym. Quebeck*, p. 179 (1887).

amplipennis (Motschulsky).

Homolus ? amplipennis, MOTSCHULSKY, *Bull. Soc. Moscou*, **36** : 27 (1863)[1].

[1]Ceylon.

Perisemus. amplipennis, DALLA TORRE, *Cat. Hym.*, **5** : 549 (1898).

Bethylus amplipennis, KIEFFER, *Das Tierreich*, **41** : 514 (1914).

distigma Motschulsky.

Bethylus distigma, MOTSCHULSKY, *Bull. Soc. Moscou*,

36 : 27 (1863)[1]. KIEFFER, *Das Tierreich*, **41** : 514 (1914). CHATTERJEE, *Indian J. Ent.*, **3** : 163 (1941), [Early stages]. PRUTHI and MANI, *Mem. Indian. Mus.*, **13** : 428 (1942)[2], [Notes on biology], [Host : Ectoparasite of caterpillars of *Agrotera basinotata* Hamps, *Chalcidoptera straminalis* Guen., *Hyblaea puera* Cram., *Lygropia quaternalis* Zell. *Sylepta* (?) *crotonalis* and *Cacoecia* sp. The adult females are recorded from Ceylon as predators and larvae are ectoparasites of the larvae of Tea Tortrix, *Homona coffearia* Nietn.].

Goniozus montanus, KIEFFER, *Gen. Ins.*, **76** : 15 (1908).

[1]Mt. Nuwara, Elliya : Ceylon. [2]Nilambur, Madras ; Dehra Dun, Uttar Pradesh : India.

sp. Pruthi and Mani.

Bethylus sp., PRUTHI and MANI, *Mem. Indian Mus.*, **13** : 429 (1942)[1], [Host : Pink bollworm of cotton, *Platyedra gossypiella* (Saunders)].

[1]Kanpur, Uttar Pradesh : India.

Genus 53. **Goniozus** Forster.

Goniozus, FORSTER, *Hym. Stud.*, **2** : 96 (1856), [Genotype : *Goniozus claripennis* Forster]. Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 262 (1905). KIEFFER, *Das Tierreich*, **41** : 522 (1914), [Key to World species]; *Philipp. J. Sci.*, **20** : 101 (1922), [Key to Oriental species]. VOUKASSOVITCH, *Acad. Sci. Paris*, **177** : 906 (1923), [Life-history of *Goniozus claripennis* Forster]. GALLARD, *Austral. Nat.*, **5** : 172 (1924), [Binomics of *Goniozus antipodium*]. FOUTS, *Proc. ent. Soc. Washington*, **28** (8) p. 167 (1927), [*Goniozus euliae* parasitic on larvae of *Eulia velutinana* Walker]; *Ibid*, **30** (7) pp. 121-132 (1928), [Key to North American species].

borneanus Cameron.

Goniozus borneanus, CAMERON, *Entomologist*, **43** : 175 (1910)[1]. KIEFFER, *Das Tierreich*, **41** : 517 (1914).

[1]Kuching : Borneo.

depressus Kieffer.

Goniozus depressus, KIEFFER, *Insecta*, **3**: 318 (1913)[1]; *Das Tierreich*, **41** : 526 (1914).

[1]Philippines.

fulvicornis (Rohwer).

Trissomalus fulvicornis, ROHWER, *Proc. U. S. Nat. Mus.*, **49** : 233 (1916)[1]. PRUTHI and MANI, *Mem. Indian Mus.*, **13** :429 (1942)[2], [Host :

[1]India. [2]Devanhalli, Mysore : India.

Argyroplocė illepida Butler].

Goniozus fulvicornis, Rohwer, *Proc. ent. Soc. Washington*, **42** (6) p. 120 (1940), [Host : *Cryptophlebia carpophaga*].

indicus Ashmead.

Goniozus indicus, Ashmead, *Indian Mus.*, **5** (3) pp. 178-181 (1903)[1], [Host : *Scirpophaga auriflua* Zell. larvae]. Reh, *Handb. Pflanzenkrankheiten*, **4** : 366 (1925)[2], [Hosts : *Scirpophaga auriflua* Zell., *Sciropophaga intacta* Snell, *Scirpophaga monostigma* Zell. and *Scirpophaga chrysorrhoea* Zell.]. Muesebeck, *Proc. ent. Soc. Washington*, **42** (6) p. 121 (1940)[3], [Host : Larvae of *Diatraea venosata* (Walk.) and larvae of *Chilo* sp. on cholam]. Pruthi and Mani, *Mem. Indian Mus.*, **13**: 429 (1942)[4], [Hosts : Larvae of *Emmalocera depressella*, root-borer of sugar-cane; *Scirpophaga intacta* Snell; *Scirpophaga chrysorrhoea* Zell.; *Scirpophaga monostigma* Zell.; *Scirpophaga* sp.].

[1]Champaran, Bihar : India.

[2]Oriental region.

[3]Coimbatore, Madras, State : India.

[4]Pusa, Bihar ; Delhi : India.

Goniozus cuttackensis, Lal, *Indian J. Ent.*, **1** (2) pp. 51-52 (1939)[5], [Host : Pupa in burrow of stem-borer of sugar-cane].

[5]Cuttack, Orissa : India.

manilensis Kieffer.

Goniozus manilensis, Kieffer, *Philipp. J. Sci.*, **20** : 101 (1922)[1].

[1]Laguana, Los Banos, Luzon : Philippines.

morindae Kurian.

Goniozus morindae, Kurian, *Agra Univ. J. Res.* (*Sci.*), **1** : 66-67 (1952)[1], [Host : *Asphondylia morindae* Mani, from gall No. 288 on flowers of *Morinda tinctoria* Roxb.].

[1]Tanjore, Madras state: India.

nephoterycis Kurian.

Goniozus nephoterycis, Kurian, *Agra Univ. J. Res.* (*Sci.*), **1** : 63-65 (1952)[1], [Host : *Nephopteryx* larvae binding leaves of *Cassia fistula*].

[1]Pusa, Bihar : India.

philippinensis Ashmead.

Goniozus philippinensis, Ashmead, *Proc. U. S. Mus.*, **28** : 134 (1904)[1]. Kieffer, *Das Tierreich*, **41** : 527 (1914).

[1]Manila, : Luzon Philippines.

triangulifer Kieffer.

Goniozus triangulifer, Kieffer, *Bull. Soc. ent. France*, p. 158 (1914)[1]; *Das Tierreich*, **41** : 526 (1914).

[1]Philippines.

triangulus Kieffer.

Goniozus triangulus, Kieffer, *Philipp. J. Sci.*, **20** : 102 (1922)[1].

[1]Laguana, Mount Maquiling, Luzon : Philippines.

williamsi Bridwell.

Goniozus williamsi, Bridwell, *Proc. Hawaii ent. Soc.*, **4** (1) p. 33 (1919)[1], [Host : Group of lepidopteran larvae, probably Pyralid].

[1]Los Banos : Philippines.

Genus 54. **Perisierola** Kieffer.

Bethylus, Say, *Boston J. nat. Hist.*, **1** : 279 (1836).

Goniozus (partim) , Ashmead, *Bull. U. S. Mus.*, **45** : 74 (1893).

Parasierola (partim), Kieffer, *Ann. Mus. Genova*, **41** : 381 (1904).

Perisierola, Kieffer, *Das Tierreich*, **41** : 533 (1914), [Key to species], [Genotype : *Perisierola gallicola* Kieffer]. Williard, *U. S. Dept. Agric.* (*Tech. Bull.*), **19** : 1-16 (1927), [*Perisierola emigrata* and *Perisierola hawaiiensis* found parasitising *Pectinophora gossypiella*, pink bollworm of cotton]. Myers, *Trans. ent. Soc. London*, **80** (1) pp. 121-136 (1932), [*Perisierola bogotensis* parasitise larvae of *Diatraea saccharalis*]. Richards and Thomson, *Trans. ent. Soc. London*, pp. 228-229 (1932). Muesebeck, *Rec. Indian Mus.*, **36** : 227 (1934), [Key to Indian species].

angulata Muesebeck.

Perisierola angulata, Muesebeck, *Proc. ent. Soc. Washington*, **35** : 53 (1933); *Rec. Indian Mus.*, **36** : 226 (1934)[1], [Oriental fruit moth *Grapholitha molesta* Busck. recorded as host].

[1]New South Wales : Australia.

mellipes Muesebeck.

Perisierola mellipes, Muesebeck, *Rec. Indian Mus.*, **36** : 226 (1934)[1], [Unknown host on *Margosa*].

[1]Coimbatore, Madras State : India.

nephantidis Muesebeck.

Perisierola nephantidis, Muesebeck, *Rec. Indian Mus.*, **36** : 225 (1934)[1], [Host : Xyloryctid moth *Nephantis serinopa*]. Pruthi and Mani, *ICAR Misc. Bull.*, **30** : 25 (1940), [Ramakrishna (1939) records from South India a species of *Pleurotropis* (Entedontidae), having been bred from *Perisierola nephantidis* a larval parasite of *Nephantis serinopa*].

[1]Coimbatore, Madras State : India.

Genus 55. **Parasierola** Cameron.

Parasierola, CAMERON, *Trans. ent. Soc. London*, p. 197 (1883), [Genotype : *Parasierola testaceicornis* Cameron]. KIEFFER, *Das Tierreich*, **41** : 542 (1914). RAMACHANDRA and CHERIAN, *Madras Agric. Dept.* (1927-1928), pp. 11-22 (1928), [Notes on life-history and habits of *Parasierola* sp. the Bethylid parasite of *Nephantis serinopa* and notes on secondary parasitism of *Parasierola*].

quadrifoveata Muesebeck.

Parasierola quadrifoveata, MUESEBECK, *Rec. Indian Mus.*, **36** : 227 (1934)[1], [Host : Cocoon taken from a betel leaf]. [1]Bellary, Madras state: India.

Genus 56. **Odontepyris** Kieffer.

Odontepyris, KIEFFER, *Ann. Mus. Genova*, **41** : 378 (1904), [Genotype : *Odontepyris flaviventris* Kieffer]; *Ann. Soc. Sci. Bruxelles*, **29** : 104 (1905); *Das Tierreich*, **41** : 545 (1914).

flaviventris Kieffer.

Odontepyris flaviventris, KIEFFER, *Ann. Mus. Genova*, **41** : 378 (1904)[1]; *Das Tierreich*, **41** : 546 (1914). [1]Sumatra.

Family 3. SCLEROGIBBIDAE.

Bethylinae (partim), ASHMEAD, *Bull. U. S. Mus.*, **45** : 27 (1893).

Sclerogibbini, ASHMEAD, *Canad. Ent.*, **34** : 269 (1902).

Sclerogibbinae, Kieffer : KIEFFER and MARSHALL, *Andre, Spec. Hym. Eur.*, **9** : 240 (1905). KIEFFER, *Das Tierreich*, **41** : 559 (1914).

Sclerogibbidae, RICHARDS, *Proc. Roy. ent. Soc. London*, **8** :211-223 (1939), [Revision]. REID, *Trans. Roy. ent. Soc. London*, **91** : 412-414 (1941), [Morphology]. MUESEBECK and WALKLEY, *U. S. Dept. Agric.* (*Agric. Mon.*), **2** : 734 (1951).

Genus 57. **Mystrocnemis** Kieffer.

Mystrocnemis, KIEFFER, *Ann. Soc. Sci. Bruxelles*, **29** : 109 (1905), [Genotype : *Mystrocnemis erythrothorax* Kieffer]; *Das Tierreich*, **41** : 561 (1914), [Key to species]; *Ent. Mitt.*, **14** : 23 (1925).

embiidarum Kieffer.

Mystrocnemis embiidarum, KIEFFER, *Ent. Mitt.*, **14** : 23 (1925)[1]. [1]Ceylon.

erythrothorax Kieffer.

Mystrocnemis erythrothorax, KIEFFER, *Ann. Soc. Sci. Bruxelles*, **29** : 110 (1905); *Das Tierreich*, **41** : 561 (1914)[1]. [1]Burma.

Incertae Sedis

Genus **Dolus** Motschulsky.

Dolus, MOTSCHULSKY, *Bull. Soc. Moscou.*, **36** : 27 (1863).

opacicollis Motschulsky.

Dolus opacicollis, MOTSCHULSKY, *Bull. Soc. Moscou.*, **36** : 28 (1863)[1]. [1]Ceylon.

subnitidus Motschulsky.

Dolus subnitidus, MOTSCHULSKY, *Bull. Soc. Moscou.*, **36** : 27 (1863)[1]. [1]Ceylon.

AGRA UNIVERSITY JOURNAL OF RESEARCH

NOTICE TO CONTRIBUTORS

1. The Agra University Journal of Research will publish articles embodying the results of original research, as well as critical reviews of recent research. The Journal is printed separately in two parts viz., Science and Letters and is for the time being issued twice a year, in January and July. Papers meant for inclusion in January issue must reach the Editor by end of the preceding October and for the July issue by end of the preceding April.

2. Papers intended for publication in the Journal should be sent to the Chief Editor. They are presumed to be offered to no other journal for publication. They should be type-written, double-spaced, on only one side of the paper, with ample margin for editorial notes. They should preferably be written in one of the international languages like English, German or French, and if this is not possible, a summary should always be included in English.

3. Authors must drastically *condense* their type-script and should send it in absolutely final form for printing. All tables should be numbered and must be such as can be printed within the format of the Journal. Literature should be cited either as foot-notes or at the end of the paper, arranged alphabetically authorwise, employing international symbols and contracting the titles of the periodicals in accordance with the world list of Scientific Periodicals, for example : Serial No. of the reference, name of the author, year of publication, title of paper, name of periodical, series (in brackets), volume (double-underlined), part (in brackets), page, figure and plate thus : Puri v. 1940. On the Embryology of some grasses. *Proc. Indian bot. Soc.*, (3)5(2) : 371, fig. 59, pl. iv.

4. Illustrations meant for inclusion in the paper must be of first class quality and should preferably be line-drawings larger than the required size on Bristol-Board and drawn with Indian ink. Each drawing should bear on the back the name of the author and the title of the paper. Photographs should be on brilliantly contrasty black-and-white smooth glossy paper and should be sent flat and unmounted. Three colour plates can be accepted in very exceptional cases. The editor will be pleased to give advice and render any other help to authors who may wish to consult him.

5. In scientific papers measures and weights should be in the metric system and fractions in decimals. Temperatures, except in medical papers, should be in centigrade degrees.

6. Failure to comply with these instructions may involve rejection of a paper. Copyright of all matter, including plates and figures, published in the Journal is vested in the University.

7. The authors will be sent one proof for correction.

8. Authors (in case of joint-authorship of a paper, each author) will receive 50 copies of reprints of their paper free. Additional copies may, however, be ordered at the time of returning the proof and these will be charged for at cost price (paper and impression charges only).

Chief Editor.

CONTENTS

PAGES

1. Parachor and Hydrogen Bonding. By R. P. SHUKLA & W. V. BHAGWAT 1
2. Ion Exchange Chromatography By R. P. SHUKLA & R. P. BHATNAGAR 9
3. Entomological Survey of the Himalayas. I.- Introduction, Description of gall midges (Itonididae=Cecidomyiidae : Diptera) and Plant galls from the Western Himalayas. By M. S. MANI 13
4. Contributions to our knowledge of Fig insects (Chalcidoidea: Parasitic Hymenoptera) from India. V.- On seven species of the genus *Philotrypesis* Forst. with a note on Unisexual variations and Polymorphism. By K. J. JOSEPH 43
5. Organic Evolution : Some Additional Notes. By M. S. MANI ... 95
6. Descriptions of some new species of gall midges (Itonididae : Diptera) from the Orient. By M. S. MANI 109
7. Descriptions of some new Chalcids (Parasitic Hymenoptera) from India. By CHANDY KURIAN 119
8. Condensation of 5-bromo-vanillin, 5-bromo-veratraldehyde, 6-bromo-piperonal and 6-nitro-piperonal with malon-o-toluidic acid. By M. C. CHACO & P. I. ITTYERAH 135
9. Condensation of cinnamaldehyde with malonanilic, malon-*o*, *m*- and *p*-toluidic and malon-1.3.4.-xylidic acids. By P. P. BAGCHI & P. I. ITTYERAH 143
10. Rotatory Dispersion of some salts of Reychler's acid with divalent metals. By O. N. PERTI 147
11. Reduction processes at the Dropping mercury Electrode in Pulsating fields : Zinc ion. By H. P. AGARWAL 155
12. Comparative studies on Budding and Grafting in loquat, *Eriobotrys japonica* Lind. By V. S. CHHONKAR & M. K. SHARMA 159
13. Fibroids in Pregnancy. By Miss A. D. ENGINEER 171
14. A critical Study of the various Methods of evaluating structural Parachors. By S. N. KAVEESHWAR & W. V. BHAGWAT 181
15. Reformatsky's condensation of Ketonic esters with halo esters. By M. B. ANTIA & P. KAUSHAL 192
16. Condensation of -3. 4-methylenedioxyphenylpropionamides with benzaldehyde, *o*- *m*- and *p*-methoxybenzaldehyde and *o*- *m*- and *p*-nitrobenzaldehydes. By T. GEORGE & P. I. ITTYERAH ... 203
17. Studies of Joshi effect in Iodine vapour under Electrodeless discharge. By A. P. SAXENA & C. N. RAMCHANDRA RAO 207
18. Activity of micro-organisms affecting Nitrogen, Phosphorus and Carbon changes in soil. By A. N. PATHAK 217
19. Fluorescence & Joshi Effect. By A.P. SAXSENA & M.V. RAMANAMURTHI 233
20. Effect of sodium dichloro-phenoxyacetate on crop weeds in wheat field. By H. K. PANDE 241
21. Catalogue of Oriental Bethyloidea. By CHANDY KURIAN ... 253

Edited by Dr. M. S. Mani, Chief Editor. Agra University Journal of Research.
Printed by H. K. Kapur at Agra University Press Agra.
Published by Dr. L. P. Mathur, Registrar, Agra University.

IN FAVOUR OF EXCHANGE

AGRA UNIVERSITY JOURNAL OF RESEARCH

Vol. III, Part 2. *SCIENCE* July 1954

Abbr. *Agra Univ. J. Res.* (*Sci.*)

PUBLISHED BY
THE REGISTRAR, AGRA UNIVERSITY
AGRA 1954
Annual subscription : Inland Rs. 15/- Foreign Rs. 20/-

AGRA UNIVERSITY JOURNAL OF RESEARCH

NOTICE TO CONTRIBUTORS

1. THE AGRA UNIVERSITY JOURNAL OF RESEARCH will publish articles embodying the results of original research, as well as critical reviews of recent research. The Journal is printed separately in two parts viz., Science and Letters and is for the time being issued twice a year, in January and July. Papers meant for inclusion in January issue must reach the Editor by end of the preceding October and for the July issue by end of the preceding April.

2. Papers intended for publication in the Journal should be sent to the Chief Editor. They are presumed to be offered to no other journal for publication. They should be type-written, double-spaced, on only one side of the paper, with ample margin for editorial notes. They should preferably be written in one of the international languages like English, German or French, and if this is not possible, a summary should always be included in English.

3. Authors must drastically *condense* their type-script and should send it in absolutely final form for printing. All tables should be numbered and must be such as can be printed within the format of the Journal. Literature should be cited either as foot-notes or at the end of the paper, arranged alphabetically authorwise, employing international symbols and contracting the titles of the periodicals in accordance with the World List of Scientific Periodicals, for example : Serial No. of the reference, name of the author, year of publication, title of paper, name of periodical, series (in brackets), volume (double-underlined), part (in brackets), page, figure and plate thus : PURI, V. 1940. On the Embryology of some grasses. *Proc. Indian bot. Soc.*, (3)5(2) : 371, fig. 59, pl. iv.

4. Illustrations meant for inclusion in the paper must be of first class quality and should preferably be line-drawings larger than the required size on Bristol-Board and drawn with Indian ink. Each drawing should bear on the back the name of the author and the title of the paper. Photographs should be on brilliantly contrasty black-and-white smooth glossy paper and should be sent flat and unmounted. Three colour plates can be accepted in exceptional cases. The editor will be pleased to give advice and render any other help to authors who may wish to consult him.

5. In scientific papers measures and weights should be in the metric system and fractions in decimals. Temperatures, except in medical papers, should be in centigrade degrees.

6. Failure to comply with these instructions may involve rejection of a paper. Copyright of all matter, including plates and figures, published in the Journal is vested in the University.

7. The authors will be sent one proof for correction.

8. Authors (in case of joint-authorship of a paper, each author) will receive 50 copies of reprints of their paper free. Additional copies may, however, be ordered at the time of returning the proof and these will be charged for at cost price (paper and impression charges only).

Chief Editor.

CALCUTTA UNIVERSITY CENTRAL LIBRARY

Agra University
Journal of Research

Vol. III, Part 2 **Science** **July 1954**

FLORAL MORPHOLOGY AND EMBRYOLOGY OF *HEDERA NEPALENSIS* K. KOCH.

By DALBIR SINGH, *B. R. College, Agra, India.*

INTRODUCTION

Hedera nepalensis is a member of the Araliaceae. Although the vascular anatomy of the flowers of the family has been worked out by Martel (6)* on *Hedera helix* and *Aralia sieboldii*, Saunders (9) on *Acanthopanax sieboldianum*, *Aralia californica*, *A.chinensis*, *Cussonia sp.* and *Hedera helix* and Eames & MacDaniels (3) on *Hedera helix*, the last two workers have given a widely conflicting account. It, therefore, becomes necessary to reinvestigate some of the members for confirmation.

Ducamp (1 & 2) reported *Polygonum*-type of embryo sac in *Aralia cachemirica*, *A. racemosa*, *A. spinosa*, *Fatsia japonica* and *Hedera helix*. Schnarf (10), who reviewed the early embryological literature on the Araliaceae, also reported the *Polygonum*-type of embryo sac. But Gopinath (5) finds that, whereas the embryo sac develops generally according to the *Polygonum*-type in *Brassaia actionophylla*, *Hedera australiana*, *Heptapleurum venulosum*, *Panax fruticosa* and *Polyscias pinnata*, there are a few instances in *Hedera australiana* and *Polyscias pinnata*, where it shows a tendency towards the bisporic type. In *Brassaia actinophylla* he regards that the embryo sac development tends towards the *Oenothera*-type.

It is to solve these issues regarding the vascular anatomy of the flower as well as the embryology that this problem was undertaken by me, on the suggestion of Mr. R. L. Paliwal, who was good enough to supply the material, preserved in formalin-acetic-alcohol, collected by him from Mussoorie in 1950.

---

*Quoted in Puri (8).

MATERIAL AND METHOD

The material was dehydrated through normal-butyl as well as tertiary-butyl-alcohol series, of which the former proved to be better. Serial microtome sections, cut 6 to 18 micra thick, were stained with Heidenhains-iron-alum-haemotoxylin and differentiated with picric acid. For the anatomical studies of the flower the slides were stained with safranin and fast-green.

EXTERNAL MORPHOLOGY

The flowers are hermaphrodite. They are borne on a compound inflorescence forming globose pedunculate umbels, arranged in corymbs. Flowers are pentamerous but sometimes the number of the petals and stamens is six each. The ovary is inferior, pentacarpellary, syncarpous, pentalocular with a single unitegmic, anatropous and pendulous ovule in each locule. The style is columnar.

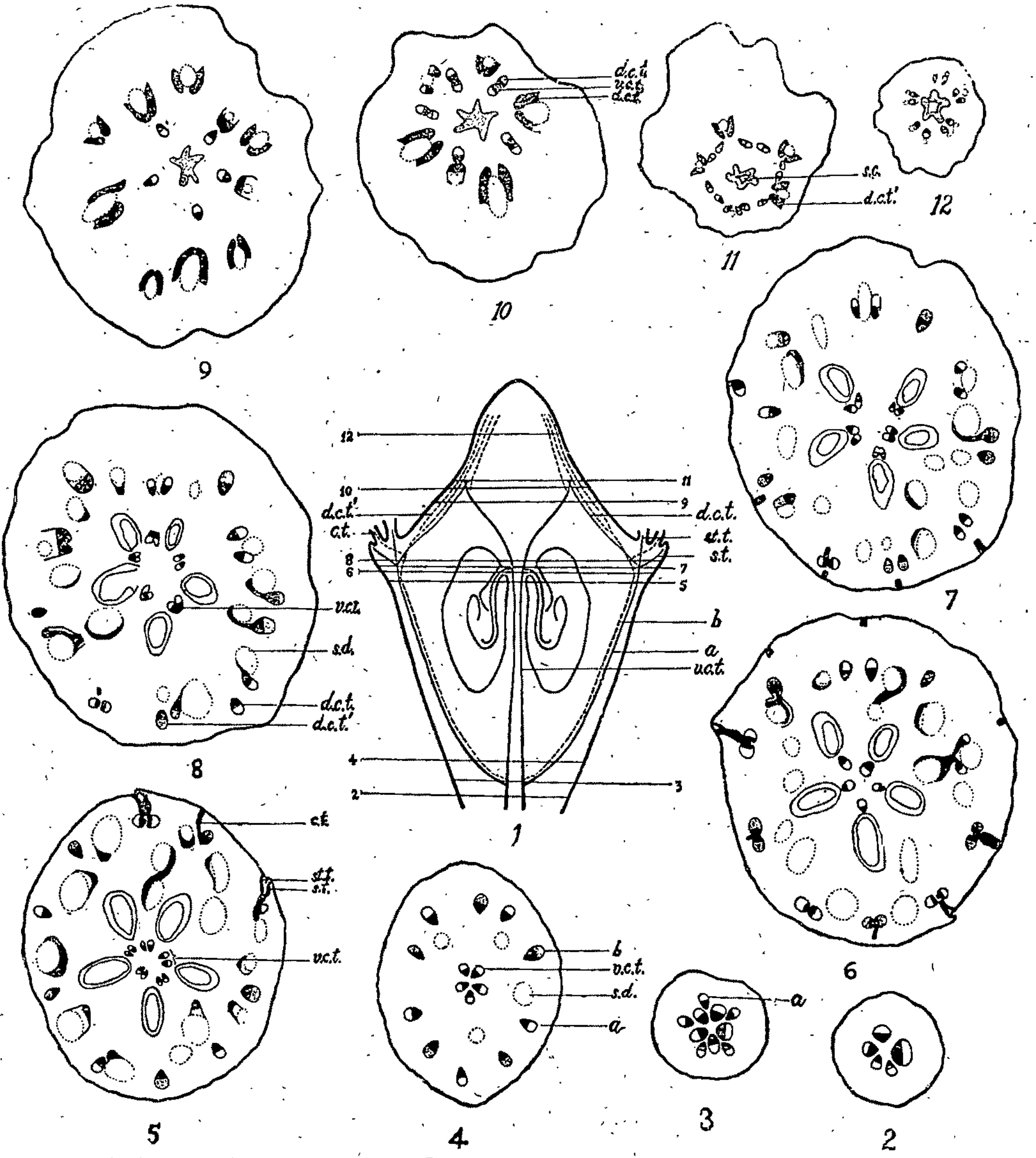
VASCULAR ANATOMY OF THE FLOWER

The ovary has an epidermis with a thick cuticle. There are two or three compact layers of parenchymatous hypodermis followed by aerenchyma, which is absent from the style whose tissue is, therefore, formed of compact cells of parenchyma. Calcium oxalate crystals are present in all tissues of the ovary, as well as, in other parts of the flower.

The index figure 1 represents a diagrammatic longitudinal section of the flower showing its vascular supply; the numericals represent the levels of the figures in transverse section.

The transverse section of pedicel (fig. 2) shows five collateral and endarch vascular bundles in a ring, which on entering the base of the ovary divide soon into two rings of five vascular bundles each (fig. 3), those of the outer ring lie alternately with those of the inner, and in their upward course, move obliquely out to lie nearer the periphery. The inner ring again divides and forms two concentric rings of five vascular bundles each. The outer ring of the newly divided bundles has its course directed obliquely upward. Finally these strands come to lie alternately with those of the outer ring of vascular bundles (fig. 4) and the ovary at this level thus shows two rings, the inner forms the ventral carpellary traces, while the branches from the outer supply the sepals, petals, stamens and the remaining bundles form the dorsal carpellary traces. The method of branching of these bundles (figs. 5, 6, 7) is as follows:

The outer ring of ten has two sets of vascular bundles (a & b), five lying in the sepal radii (a) alternate with the others (b)



Figs. 1-12.—Vascular supply of the flower.

Fig. 1, Diagrammatic l. s. flower. Figs. 2-12, t. s. flower at levels 2-12 in fig. 1, × 13. (*a.* vascular bundles supplying traces to calyx, stamens and carpels; *b.* vascular bundles which supply petals and carpels; *c. t.* petal trace; *d. c. t.* dorsal carpellary trace on the sepal radius; *d. c. t.* dorsal carpellary trace on the petal radius; *s. c.* stylar canal; *s. d.* secretory duct; *s. t.* sepal trace; *st. t.* stamen trace; *v. c. t.* ventral carpellary trace.)

on the petal radii. The former divide and give out traces to the calyx, androecium and the carpels. The latter enter the petals and carpels after dividing into two each. All these carpellary bundles, either from the sepal radii or from petal radii, constitute the dorsal carpellary traces, which in most cases are formed of paired bundles. These findings are in close agreement with those of Saunders (9), who differs in stating that the dorsal carpellary traces, coming from the sepal radii alone divide, each forming a pair, while those from the petal radii pass without any division. Eames & MacDaniels (3) have, however, figured free traces to the sepals, petals and stamens in *Hedera helix*, which separate from the main cylinder at the base of the flower and travel throughout the ovary wall as such. The course of the dorsal carpellary traces is obliquely upward running along the ovary wall. The further course of these bundles into style is given after the description of the ventral carpellary traces.

The ventral carpellary traces are collateral and endarch, as shown above, in the base of the flower (fig. 4). In the region of the ovules, however, their orientation changes from endarch to exarch as follows : each ventral carpellary bundle divides into two so that the inner ring, for a short distance, is formed of five pairs of vascular bundles (fig. 5), the traces from the adjacent vascular bundles fuse and produce five exarch bundles (fig. 6), which send branches, one to each of the five ovules and divide again, producing two vascular traces each (fig. 7). The adjacent daughter traces, of two separate pairs, unite and produce a single vascular strand. The number of vascular bundles in the inner ring again becomes five. The orientation, however, remains exarch (fig. 8). Saunders (9) has described that the placental supply is formed of twin bundles, which after providing the traces for the ovules fuse with the paired dorsal carpellary traces from the sepal radii and then diverge and fuse with the dorsal carpellary bundles from the petal radii and pass into the style. Eames & MacDaniels (3) have, however, shown that the five ventral carpellary bundles, after giving off a branch to each of the five ovules, pass as such into the style.

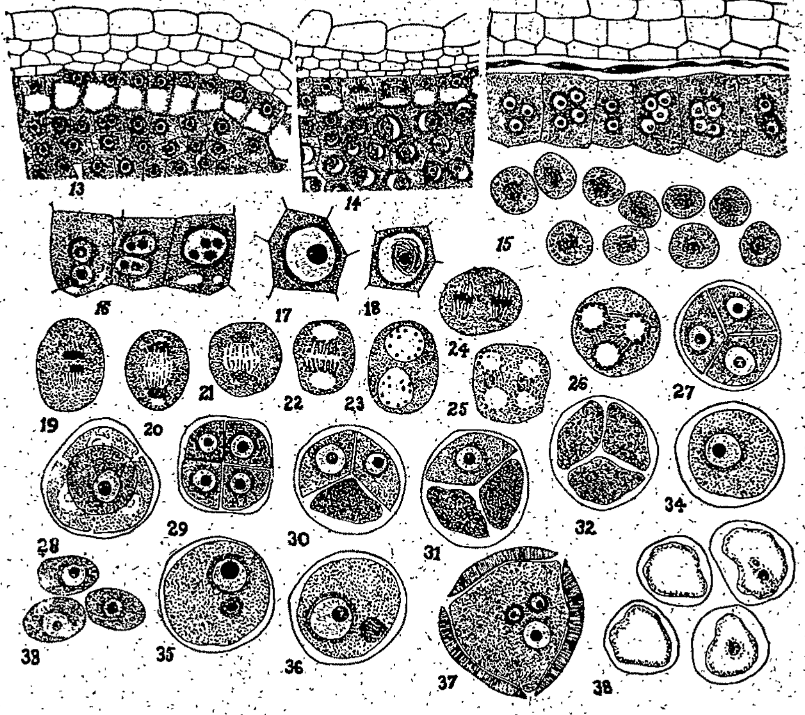
A transverse section of the ovary at the base of the style (fig. 9) also shows two rings of vascular bundles. Those of the inner ring, which are inversely oriented, are the ventral carpellary bundles, while those of the outer, which are formed of paired bundles with normal orientation, are the dorsal carpellary bundles. The dorsal carpellary bundles from the sepal radii fuse with the ventral carpellary bundles, which meet them half-way in their obliquely outward course. (fig. 10). The fused products of these bundles now divide once again to form ten vascular strands, which unite with the remaining dorsal bundles (d. c. t.) on the outer ring (fig. 11) to form ten vascular bundles grouped into five patches. They travel unchanged throughout the length of the style (fig. 12) and terminate only at the base of the stigma. Eames & MacDaniels (3) have, however, figured the five ventral carpellary and five dorsal carpellary bundles passing into the style, which thus receives ten vascular bundles in *Hedera helix*. Saunders (9) has shown that the vascular scheme in the ovary of *Acanthopanax sieboldianum* is exactly what is shown above in the case of *Hedera nepalensis*. In *Aralia californica* and *A. chinensis*, she describes that the sterile carpellary bundles soon cease to be traceable and thus, only the fused traces pass into the style which receives only five vascular bundles.

SECRETORY DUCTS

A large number of the secretory ducts are present in the ovary. These ducts are schizogenous in origin and the epithelial cells lining them are thin-walled with dense cytoplasm and nucleus. Their size and number are very variable. Some of them originate in the ground tissue of the ovary at its base (fig. 4), others arise higher up in the same tissue or in the phloem. A secretory duct always receives a branch from one of the vascular bundles of the outer ring. This branch runs to a longer or shorter distance with the duct and later disappears.

Microsporogenesis

The transverse section of a young anther shows an epidermis, endothecium, two middle layers and a single layered tapetum (fig. 13). Epidermal cells are thin walled and their radial walls show signs of degeneration in anthers with microspores. Finally epidermis is completely lost. The endothecium develops the usual fibrous thickening and becomes the outermost layer. Of the two middle layers the inner one degenerates first (fig. 15) followed by the outer, so that, at the microspore tetrad stage, the middle layers can be seen only as dark streaks. Gopinath (5) has reported two middle layers in *Brassaia actinophylla* and only one in *Panax fruticosa* and *Hedera australiana*. The latter observation is probably the result of the early degeneration of inner middle layer.



Figs. 13-38.—Microsporogenesis and development of the male gametophyte.

Fig. 13. l. s. anther lobe showing wall layers and microspore mother cells, note the uninucleate tapetal cells each having a big vacuole. × 440. Fig. 14. l. s. anther lobe, showing the mitotic divisions of the tapetal nuclei, the microspore mother cells are also undergoing reduction. × 440. Fig. 15. l. s. anther lobe showing multinucleate tapetum and degeneration of the inner middle layer. × 500. Fig. 16. tapetal cells showing the fusion of the nuclei. × 500. Fig. 17-22. microspore mother cells undergoing various phases of reduction division. × 795. Figs. 23-26. mother cells showing homotypic division. × 795. Figs. 27, 28, 29. tetrahedral and isobilateral tetrads. × 795. Figs. 30-32. microspore tetrads with some degenerating microspores. × 795. Fig. 33. young microspores. × 795. Fig. 34. uninucleate pollen grain. × 795. Fig. 35. two-celled pollen grain. × 795. Fig. 36. two-celled pollen grain showing the division of the generative cell. × 795. Fig. 37. three-celled pollen grain. × 795. Fig. 38. non-viable pollen grains. × 795.

The tapetum is formed of big and highly protoplasmic cells, which in the beginning are invariably uninucleate and have a conspicuous vacuole (fig. 13). Later the tapetal nuclei divide and the cells become multinucleate (figs. 14,15). Gopinath (5), however, has reported uninucleate tapetum in *Hedera australiana* and binucleate in *Panax fruticosa* and *Brassaia actinophylla*. The present investigation on *Hedera nepalensis* shows that the nuclei of the multinucleate tapetum fuse at a later stage so that it again becomes uninucleate (fig. 16). The tapetal cells finally degenerate *in situ.*

The sporogenous cells, after a number of divisions, give rise to a compact tissue of microspore mother cells (fig. 13) which separate while undergoing reduction division. The heterotypic division (figs. 17-22) is soon followed by the homotypic (figs. 23-26) and the wall formation is simultaneous. The microspore tetrads show both tetrahedral and isobilateral arrangements (figs. 27-29). It is interesting to find some degree of degeneration among microspores. All microspores of a very large number of tetrads are functional. Sometimes, however, one, two or all the microspores of a tetrad may degenerate (figs. 30-32).

MALE GAMETOPHYTE

The young microspores are full of dense cytoplasm with a big nucleus in the centre. They are more or less ovate in shape (fig. 33). Each microspore enlarges and becomes somewhat spherical (fig. 34). Its nucleus divides to form a vegetative and a generative cell (fig. 35). The latter again divides in the pollen grain itself (fig. 36) and results in the formation of two sperm cells. The mature pollen grain (fig. 37) is a tricelled structure with a thick unadorned exine discontinuous at the three germ pores. The intine is thin and continuous. Both viable and non-viable pollen grains are formed. The former are three celled and full of cytoplasm while the latter are empty (fig. 38).

OVULE

One, two or three ovules may start developing in each locule as small protuberances from the placenta (fig. 39). However, the lowermost only reaches maturity. The ovules are anatropous and pendulous with a well developed vascular supply (fig. 40).

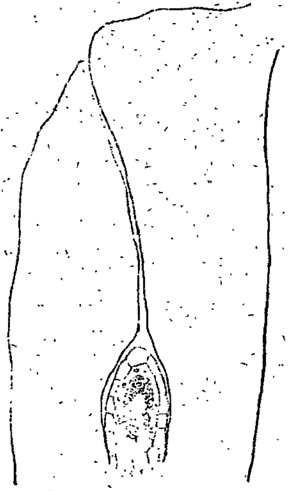
The primordium of the single integument develops from the base of the nucellus; it becomes quite massive and completely envelops the thin nucellus, leaving only a narrow micropyle (fig. 41). The nucellus starts to degenerate from the top (fig. 42), while its lower part is crushed later (Fig. 43), by the downward growth of the embryo sac forming a black degenerate mass of cells at the chalazal end of the embryo sac, which appears to have been mistaken for hypostase by Gopinath (5) in *Panax fruticosa* and *Hedera australiana*.

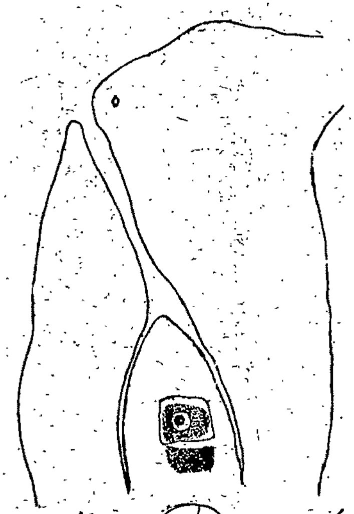
Pigott (7) in *Nothopanax arboreum* and Gopinath (5) in *Hedera australiana* and *Polyscias pinnata*, have reported a well developed obturator. I have only seen some cells rich in protoplasmic contents with conspicuous nuclei, in the funiculus near the micropyle (fig. 40). These may only be considered as the obturator initials which do not develop further.

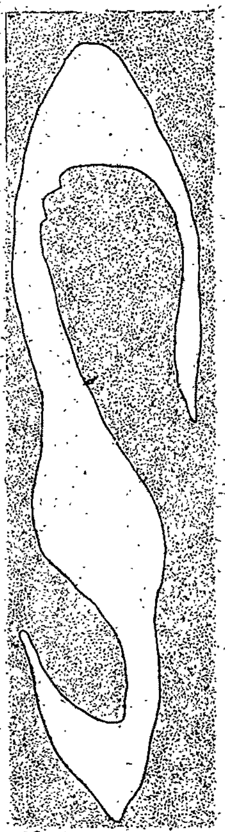
Megasporogenesis

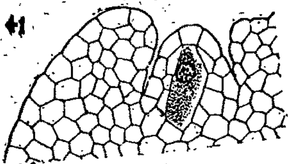
A single archesporial cell is differentiated in the hypodermal region of the nucellus. It may function directly as megaspore mother cell in a limited number of cases (fig. 44). Usually, however, it cuts off a parietal cell which either degenerates as such (fig. 45) or it may further divide and form wall layers (figs. 46—48).

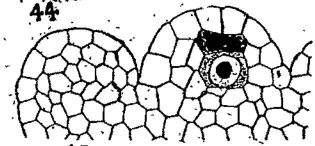
The megaspore mother cell divides and forms the dyad (figs. 47, 48). In majority of the cases one of the dyad cells, usually the micropylar (fig. 47) and sometimes the chalazal (fig. 48), functions and undergoes one more division to form megaspores. On account of the division of only one dyad cell a row of three cells is formed consisting of two megaspores and one undivided dyad cell (figs. 49, 50) . This dyad cell ultimately degenerates as such. In a few cases both the dyad cells divide to form a linear tetrad of megaspores (fig. 51). These findings, therefore, differ from those of Gopinath (5) on *Hedera australiana* and *Polyscias pinnata* who has reported that one of the dyad cells degenerates showing a tendency towards the bisporic type of development. Gopinath's findings seem to be the result of his not being able to see the divisions of the functional dyad cell and early degeneration of other dyad cell. The embryo sac which always develops in this species from one of the megaspores, shows monosporic type of development. Formation of three cells has also been reported

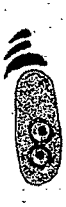

42

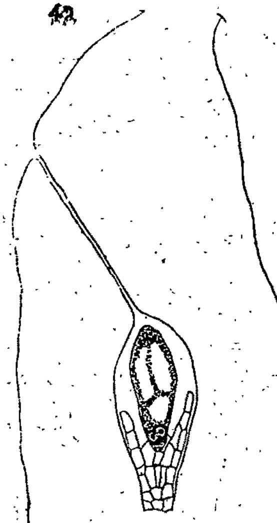

41

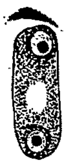

39

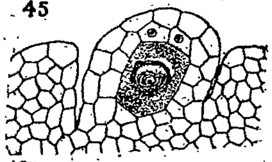

44

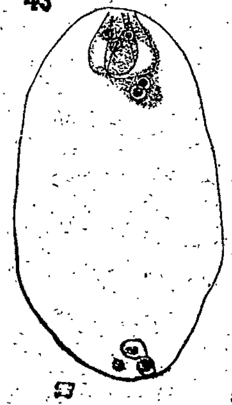

45

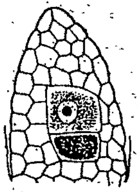

52

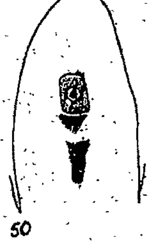

43

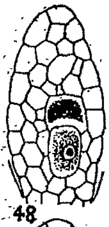

53

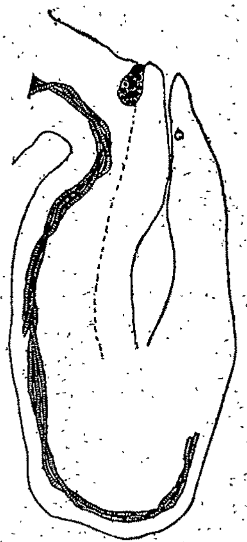

46

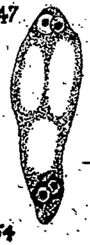

55

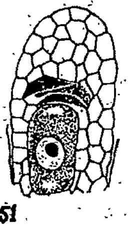

47

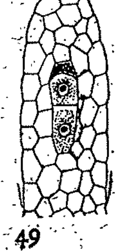

50


48


40


54


51


49

by Ducamp (2) in *Aralia racemosa* who clearly describes a monosporic embryo sac in the plant.

FEMALE GAMETOPHYTE

The functional megaspore enlarges considerably, its nucleus always lies in the centre (fig. 51), where it divides to form two nuclei, (fig. 52), which travel to the poles, with a vacuole appearing in the centre of the embryo sac (fig. 53). The divisions of the primary micropylar and the chalazal nuclei are simultaneous, which thus form a four nucleate embryo sac (fig. 54).

On account of complete degeneration of the nucellus by this time, the four nucleate embryo sac is directly enveloped by the integument. The chalazal end of the embryo sac is narrow and pierces through the chalazal portion forming a pouch-like structure. Sometimes this end is covered by the degenerating cells which hinder the observation of the embryo sac nuclei in this part. In *Brassaia actinophylla* Gopinath (5) has reported that only four nuclei are seen in the micropylar end while no nuclei are seen in the chalazal end, a stage comparable with the *Oenothera* type of the embryo sac development. A careful examination may reveal the presence of chalazal quartet of nuclei in the narrow end hidden under the nucellar cells.

The mature embryo sac is a seven-celled structure, with a three-celled egg apparatus at the micropylar end, three antipodal cells at the chalazal end and two free polar nuclei situated just below the apparatus (fig. 55). The synergids are pear-shaped and have a big vacuole at their lower end with nucleus lying just above it. The antipodals are ephemeral and degenerate early.

Figs. 39-55.—Development of ovule and embryo sac.

Fig. 39. l. s. part of ovary showing two ovules. x 300. Fig. 40. l. s. ovule showing the vascular supply in the funiculus and initials of the obturator as differentiated cells near the micropyle. x 75. Fig. 41. l. s. ovule at the dyad stage. x 440. Fig. 42. l. s. ovule at bi-nucleate embryo sac stage. x 440. Fig. 43. l. s. ovule at four nucleate embryo sac stage. x 440. Fig. 44. hypodermal megaspore mother cell in division. x 660. Fig. 45. megaspore mother cell with degenerating parietal cell. x 660. Fig. 46. megaspore mother cell in prophase with primary parietal cell divided anticlinally. x 660. Fig. 47. dyad, the chalazal cell is degenerating. x 660. Fig. 48. same as above but with micropylar dyad cell degenerating. x 660. Fig. 49. a row of three cells, of which the lower two are megaspores and the upper is the degenerating dyad cell. x 660. Fig. 50. same as above but the micropylar megaspore is functioning. x 660. Fig. 51. linear tetrad of megaspores of which the chalazal is functioning. x 660. Figs. 52, 53. bi-nucleate embryo sacs. x 660. Fig. 54. four-nucleate embryo sac. x 660. Fig. 55. mature embryo sac. x 660.

SUMMARY

Flowers formed in umbels of corymbs are pentamerous with inferior ovary. The vascular supply in the flower is formed of two rings of vascular bundles in the ovary, the inner of five and the outer of ten. Those of the inner ring form the ventral carpellary traces and supply the ovules. From the alternate bundles of the outer ring, branches enter into the sepals and stamens and the remaining bundles form the dorsal carpellary traces. The remaining bundles of the outer ring supply the petals and form the dorsal carpellary traces. Secretory ducts are common in the flower. The microsporogenesis is normal. Both isobilateral and tetrahedral tetrads of microspores are formed. In some cases one, two or even all the micro- spores of a tetrad may degenerate. Pollen grains are shed at 3 celled stage. The ovules are unitegmic, anatropous and pendulous. The development of the female gametophyte follows *Polygonum* type.

ACKNOWLEDGMENTS

I am grateful to Prof. Bahadur Singh for valuable suggestions and help in the preparation of this paper and to Sri R. L. Paliwal for the guidance and for material, which I received from him. My thanks are also due to Sri M. B. Raizada for kindly identifying the plant, to Prof. P. Maheshwari for the loan of some literature and to Dr. R. K. Singh, Principal, B. R. College, Agra, for the facilities and encouragement.

LITERATURE CITED

1. DUCAMP, L. 1901. Développment de l' embryon chez le Lierre *Hedera helix*. *C. R. Acad. Sci. Paris*, **133** : 651-653.
2. DUCAMP, L. 1902. Recherches sur l' embryogénie des *Araliacées*. *Ann. Sci. Nat. Bot.*, (8) **15** : 311-402.
3. EAMES, A. J. and MACDANIELS, L. H. 1947. "An Introduction to Plant Anatomy". New York.
4. GOPINATH, D. M. 1943: Reversed polarity in the embryo sac of *Heptapleurum venulosum*. *Curr. Sci.*, **12** : 58—59.
5. GOPINATH, D. M. 1944. Gametogenesis and embryology in a few members of the Araliaceae. *Proc. Indian Acad. Sci.*, (B) **20** : 175—186.
*6. MARTEL, E. 1908. Contribuzione all anatomia del flore dell' *Hedera helix*, dell' "*Aralia sieboldii*" e del "*Cornus sanguinea*". *Mem. Acad. Sci. Torino*, (2) **58** : 561—579.
*7. PIGOTT, E. M. 1914. Notes on *Nothopanax arboreum* with some reference to the development of gametophytes. *Trans. Proc. New Zealand. Inst.* **47** : 599—612.
8. PURI, V. 1951. The rôle of floral anatomy in the solution of morphological problems. *Bot. Rev.* **17** : 471—553.
9. SAUNDERS, E. R. 1939. "Floral morphology". Cambridge.
10. SCHNARF, K. 1931. "Vergleichende Embryologie der Angiospermen". Berlin.

---

* Not consulted in original.

STUDIES IN THE FAMILY LORANTHACEAE

List of new hosts of *Dendrophthoe falcata* (L. f.) Ettings.,[1] its relations with hosts, the anatomy of its seedling and mature haustorium.[2]

By Bahadur Singh, *B. R. College, Agra.*

Introduction

Dendrophthoe falcata, the most common of the destructive parasites of the family Loranthaceae in India, grows on a large variety of trees and shrubs. It is dispersed by birds which eat its fruits and discharge the seeds uninjured (16). Some of the valuable Indian trees yielding timber or fruits, or having other economic uses, are damaged by the parasite; the exact extent of damage and the spread of the parasite in India has not been investigated so far. Fischer's (9) is perhaps the only paper which gives the distribution, as well as a long list of as many as 153 hosts. Srivastava (21), Sayeed-ud-Din and M. A. Salam (17) and Ezekiel (8) have added four new hosts to this list.

The present paper, besides interpreting Fischer's findings, also gives a list of 34 new hosts found in the neighbourhood of Saharanpur and Mohand forests in the western part of Uttar Pradesh (India).

The morphology of the haustorium, as shown by the anatomy of this organ, is interesting. Its nature in various members of the family has been reported to differ a good deal. Thus Mc-Luckie (15) states that in *Phrygilanthus celastroides* the first organ to develop in a germinating embryo is a root which is devoid of a root cap. Skene (19) remarks that the haustorium of *Viscum album* is not a root structure at all. It is exogenous and produces exogenous branches. Thoday (24) says that *Hyphear europaeum* (*L. europaeus*) has a plastic haustorial tissue in which it is difficult to see any root-like feature. About *Viscum album* he states that "The primary haustorium and the cortical strands, while exhibiting a high degree of plasticity, behave consistently and follow a definite pattern in their growth and differentiation which is neither that of a root nor that of shoot."

---

[1] The members of Loranthoideae which appear in this paper have been named after Danser (3, 5). Names in brackets are older synonyms of only such Loranthoideae as are referred to for the first time; see also Singh (18).

[2] The term haustorium denotes the organ of a seedling that enters the host; outgrowths from adventitious roots entering the host have been described as suckers.

The present investigation, however, shows that in *D. falcata* the haustorium is a stem-structure covered over by closely packed sheaths that arise in acropetal succession, but become obscured in the mature haustorium.

MATERIAL AND METHODS

Seedlings of *D. falcata* were fixed in formalin-acetic-alcohol, infiltrated through N-butyl alcohol series, imbedded in paraffin and microtomed. Serial sections were cut along (a) transverse plane, (b) longitudinal plane of the entire seedling, and (c) longitudinal sections of the haustorium at right angles to the previous planes. The description of the haustorium would show that tangential sections of the host at the point of infection are of importance in deciding the morphological nature of the haustorium. Tubeuf (25) and Thoday (24) seem to be the only other persons who have tried such sections. Thoday (24) remarks about earlier workers that "Had they cut tangential sections at an early stage of the establishment of the seedling they could not have missed the obvious bilateral symmetry."

Sections of 'old burrs' with haustoria *in situ* were prepared by grinding technique (13). The stains used for anatomical study were a combination of safranin and fast green. For sections of old burrs these stains had to be considerably diluted to get the proper tint.

EXTERNAL MORPHOLOGY OF THE PLANT

Danser (4) remarks that *D. falcata* is "extremely polymorphous." I have observed that the haustoria of the parasite, piercing the infected branches, form burrs of varying sizes in different hosts. The size of a burr also differs according to the age and thickness of a branch; on thin branches the swelling is small, on larger branches, where the parasite has lived for a longer period, the burr becomes very large. On some mango trees the hypertrophy of the host may reach the size of a man's head, but in such cases, as a rule, more than one parasite is responsible. "Burrs" with a diameter of four to six inches are more common on the mango, one of the most heavily attacked species in Uttar Pradesh.

In some specimens, besides the haustorium, there are adventitious roots running lengthwise externally along the stem of the host. These roots are of varying lengths. In some cases they die quite early, in others they persist throughout the life of the plant and reach a length of one to two feet; one such root was found to be as long as one metre. Such roots have also been described by Skene (19) in several other members of the family.

The roots of *D. falcata* put out suckers, at intervals, into the tissues of the host. Sometimes, however, roots are found to hang down and twine like tendrils. If their tips dry up, lateral roots are given out which hang in the same manner. Such hanging roots are also described by McLuckie (15) in *Phrygilanthus celastroides* and by Skene (19) in twining species of *Struthanthus*.

Shoots commonly arise from these adventitious roots, generally taking their origin opposite a sucker, but they are also found, though rarely, growing from a place where no sucker is formed. Adventitious shoots of the latter type sometimes also occur on hanging roots.

Leaves in young specimens are generally alternate, in older plants opposite and decussate. The stem is robust, with strong branches, and the nodes more or less flattened in young specimens. Branches hang down to a length of about a meter or so.

RELATION OF THE PARASITE WITH ITS HOST

(a) *Choice of host*

D. falcata is one of the most widely spread species of the Loranthaceae, counting among its hosts species of plants belonging to widely different groups. Fischer (9) names no less than 153 species. Srivastava (21) mentions as new hosts *Psi-*

dium guyava and *Citrus medica* var *acida*; Sayeed-ud-Din and M. A. Salam (17) add *Millingtonia hortensis*, and Ezekiel (8), p. 162), *Eugenia jambolana* to this list.

Although *D. falcata* is found growing on plants belonging to very many species of dicotyledons and some gymnosperms, no monocotyledonous host has yet been discovered. Dr. van Leeuwen observed *Dendrophthoe pentandra* growing on several young monocotyledonous plants but it seldom developed on large ones. However, Arens (1) reports (*Loranthus sphaerocarpus*) *Macrosolen cochinchinensis* growing on *Dracaena* spp. The list of new hosts found by me also shows only dicotyledonous plants belonging to very widely separated orders.

Fischer (9) remarked that the failure of the parasite to attack a particular host is due to "definitive repulsion or inhibition of some kind." He states by way of an example that the parasites of this family are not found growing on plants of their own species, although they may grow on other species or genera of the Loranthaceae. The present author has, however, observed at least one or two definite cases of cannibalism in this species. In one case a seedling of *D. falcata*, which survived only for one year, was found growing on the stem of the same species with the haustorium penetrating deep and causing slight swelling at the place of infection. In another case it was observed that a sucker from one of the roots of *D. falcata* entered another root of the same plant. Herbert (12) also records that in rare cases the root of *Nuytsia floribunda* sends a sucker into another root of the same plant.

Seedlings of *Macrosolen cochinchinensis* van Tiegh growing on leaves of the same plant have also been observed by me. It is true, as Fischer remarks, that there is no chance for such seedlings to survive long. Their failure, however, may be due not to any repulsion or inhibition, as suggested by Fischer, but merely to lack of nutrition in an unsuitable position. These facts and Skene's observations (19) on certain Loranthaceae that some suckers which arise from the parasite may enter even its own branch, go against Fischer's theory of repulsion. Miss Stevenson's observations (22) on *Korthalsella lindsayi* are conclusive proof against Fischer's theory. She found many individuals of *Korthalsella* *lindsayi* parasitic on other plants of the same species. She also describes seedlings of *Korthalsella salicornioides* growing on the parent plant.

Fischer (9) says that different types of soils and ordinary climatic variations seem to have no effect on the growth of the parasite. He adds that some species, not infected in a particular locality, are found to be heavily infected in a neighbouring area. This fact, however, does not prove Fischer's statement. It may be that the parasitic species which appear morphologically identical consist of biological races, as in the rusts. Thus in one locality, a particular plant may be infected while in a neighbouring locality it may escape infection because of the absence of that physiological form. Heavy infection of another host may be due to another form. *D. falcata* may prove to be a case of this type, for Tubeuf (25) has already found such races in *Viscum album.* The first grows on a pine and is not transferred by seed or otherwise to other deciduous trees. The second occurs normally on the silver fir but cannot be grown on other species of *Abies.* The third occurs on apple, pear, poplar and oak, and is divided into sub-races with more or less sharply marked differences. In light of these observations of Tubeuf it is desirable to study the genetical constitution of the races of *Viscum album* and also to find out if *D. falcata* shows some genetic forms.

(b) *Effect of the parasite on hosts*

The effects of parasitic attack vary according to the host. On trees like *Bassia latifolia*, *Ficus bengalensis*, *Ficus religiosa*, *Mangifera indica*, *Mimusops elengi*, it has been observed by me that the growth of the parasite, even for many years, is not able to kill the host. Fischer also states that in such cases, although the injury is considerable, the only harm done is to diminish the yield of fruits. Bamber (2, p. 65), writes that *D. falcata* is destructive to *Acacia*, *Mangifera*, *Melia*, *Morus*, *Pyrus* and *Quercus.* The present author has seen that on small trees like those of *Melia azedarach* the damage is very marked and the host sheds its leaves much earlier than normally, though the new leaves again appear in the normal season. It has been observed that the parasite proves destructive to *Dalbergia sissoo* if infection is allowed to continue unhindered for some years.

SEEDLING

The mature seed possesses a somewhat peg-shaped straight embryo, whose 'radicle end'[3] forms the knob and the fused cotyledons have a pointed tip (Fig. 1). Near the proximal end the cotyledons are free and between them there is a small plumule. The endosperm surrounds the embryo, excepting at its radicle end. The seed is devoid of any seed-coat, but has a viscid covering derived from the innermost few layers of the fruit wall. On account of the viscidness, seeds can stick to any object they may fall upon. Only those seeds, however, germinate successfully which fall on a branch. Seeds that lie on objects other than plants do not show successful germination.

At the time of germination the 'radicle end', from which the haustorium arises, bends sharply towards the branch of the host to form a right angle with the fused cotyledons. As it bends the end also swells considerably and forms an irregular pad or hold-fast (Figs. 2, 3 *pd*) against the bark of the host. In *Viscum album*, however, there is a considerable elongation of the hypocotyl before it presses itself against the host (11, 24, 25). From the centre of this pad or hold-fast arises the haustorium (Fig. 3*h*) that enters the host just as in *Viscum album* (11, 24, 25). The host tissue reacts to the entry of the haustorium by developing a 'burr' around it. A haustorium dissected out of a young burr is found to possess a more or less conical axis surrounded by a number of irregular sheaths of different sizes from the base of the haustorium to its apex (Fig. 4 *s*1-6). The method of origin of these acropetally arising sheaths, as well as, the anatomy of the haustorium is interesting and is discussed below. On the side opposite to the haustorium arises the plumule (*pl*) bursting out near the proximal ends of the cotyledons. The plumule, as it emerges, has one or two pairs of opposite and decussately placed leaves (Fig. 2). Those that arise later on show an alternate arrangement (Fig. 5).

---

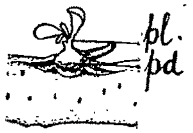
[3] Heinricher (11) states that there is no radicle in *Viscum album* which possesses only a hypocotyl. Tubeuf. (25) also writes "eine Radikula fehlt." In *D. falcata* also there is no radicle in the true sense of the word. It is for this reason that the term 'radicle end' has been used throughout the text to denote the side on which radicle should be formed.

PLUMULE

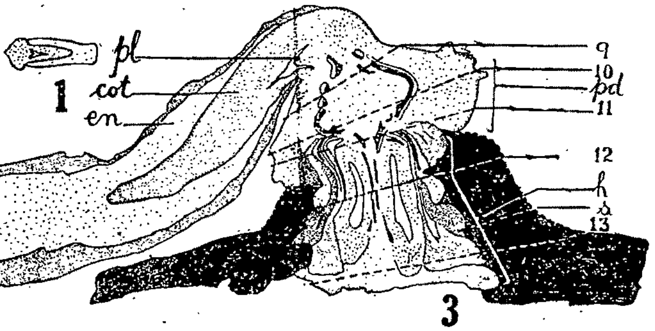
The plumule has two seminal leaves which are placed decussately to the cotyledons (Fig. 6 *l*, *cot*). As the seed germinates these leaves burst out of the proximal end of the cotyledons. The anatomy of the plumule is like that of a normal dicotyledonous stem with a comparatively narrow pith surrounded by seven to sixteen endarch, open and collateral vascular bundles (Fig. 6 *pl*, 7). The ground tissue is formed entirely of parenchymatous cells rich in cytoplasm. In the extreme base of the plumule of slightly older seedlings, however, a few patches of sclerenchymatous cells appear in the pith. The zone of hypodermal cells in this region show periclinal divisions so that cork cambium seems to be formed early. The epidermis is formed of isodiametric cells with a thin cuticle.

HOLD-FAST

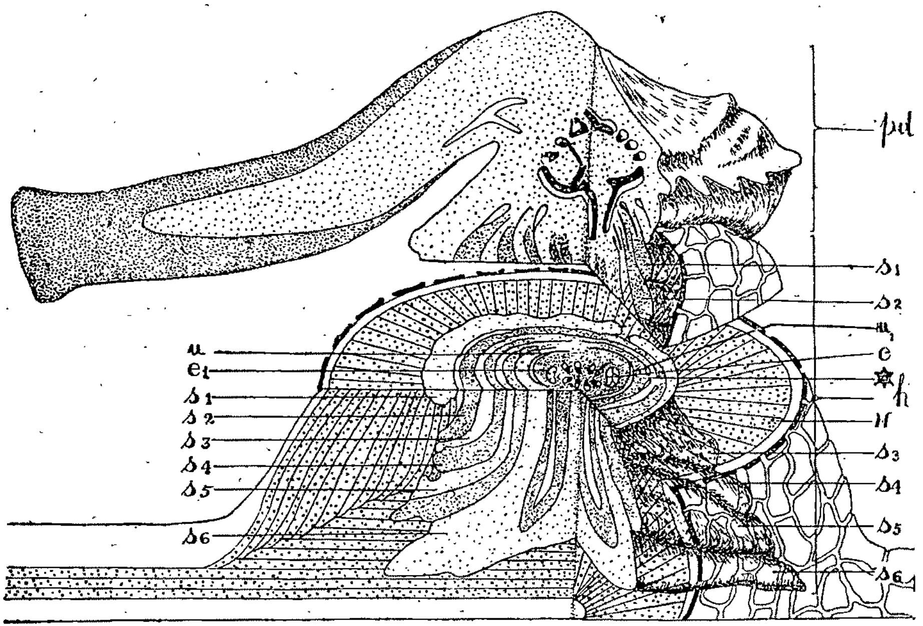
As stated above, the hold-fast is a swollen structure. It has a single layer of epidermis with a thin cuticle. The hypodermis (Fig. 8 *hy*) is also one-layered and, like the epidermis, is formed of isodiametric, thin-walled cells. The ground tissue (*c*) is formed of parenchyma full of food material. The cells of epidermis (*ep*) that come in contact with the host tissue (*ho*) show active periclinal divisions. The outermost layer in this region appears to be more or less glandular at some places and badly crushed at others. When this layer is crushed, the inner layers in succession take on the glandular function. There is also an active division of hypodermal cells and, in some cases, also of the layers of other cells of cortex in intimate contact with the hypodermis. The presence of glandular tissue of this type has also been described by Tubeuf (25) in *Viscum album* and Heil (10) in *Struthanthus* species. The cells of the cortex are isodiametric, excepting in the flanks where they are somewhat elongated. Patches of stone cells develop in the deeper part of the cortex as well as in the neighbourhood of point of attachment of the hold-fast and the host. There are fourteen or more collateral, open and endarch vascular bundles in a ring in the upper part of the hold-fast (Fig. 9) while in the middle, which is very much swollen with a proportionately large pith, there is a ring of about fifteen to twenty vascular bundles formed edentvily by branching.



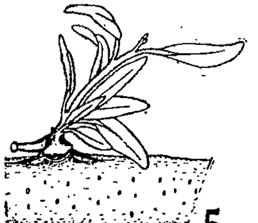
2



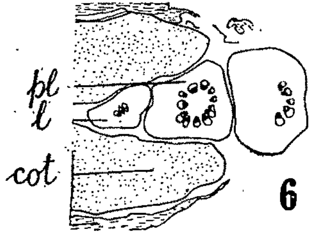
3



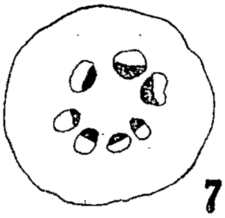
4



5



6



7

· FIG. 1. Embryo with straight axis surrounded by endosperm. FIG. 2. Seedling with its axis bent at right angles; note the opposite and decussate arrangement of leaves; *pd.* pad or hold-fast; *pl.* plumule. FIG. 3. Median l. s. of seedling; 9-13 levels of t. s. shown in illustrations bearing the same numbers; host tissue which is painted black shows a "burr"; *cot.* cotyledons; *en.* endos-

Sections lower down reveal irregularities in structure as well as in the orientation of the bundles some of which have a wider phloem than xylem. Most of the bundles bend toward the inner (centripetal) sides giving off a number of xylem processes, which are cut longitudinally and appear as short in growths jutting into the pith. In some cases phloem is found flanking the xylem (Fig. 10).

YOUNG HAUSTORIUM

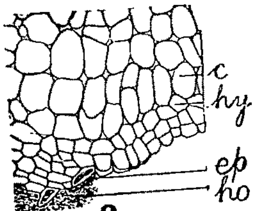
The structure of the haustoria of the Loranthaceae given by several authors is very meagre (6, 7, 10, 11, 14, 19, 20, 24, 25). From fig. 4, which is a diagrammatic sketch of the perspective view of the seedling of *D. falcata*, the following outstanding anatomical features can be easily made out in the complicated haustorium (*h*):—

The vascular supply consists mainly of small collateral, open and endarch bundles which are arranged in the centre to form a flattened ring, like that of a phylloclade, lying in a line with the longitudinal axis of the host. There is practically no pith in the haustorium. Its peripheral region is quite broad, and possesses a number of somewhat concentric folds of sheaths as stated above. These sheaths are separate one from the other by means of narrow spaces and a lining of crushed cells (Figs. 11, 12, s_{1-6}). Each sheath has ground tissue formed almost entirely of parenchymatous cells full of cytoplasm and rich food material. In longitudinal sections of the haustorium, in a line with the long axis of the host, it is seen that the outermost sheaths are smallest, while those formed progressively inward are longer and broader. They extend progressively up to the tip of the haustorium (Fig. 4s_{1-6}).

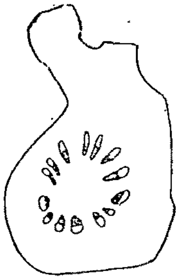
The origin of these sheaths is interesting and can be made out only on reconstruction of serial transverse sections along with

perm; *h.* haustorium; *pd.* pad or holdfast; *pl.* plumule; *s.* sheath × 24. FIG. 4. diagrammatic perspective view of seedling of *D. falcata* on host; *e* & e^1. empty spaces; s_1-s_6. sheaths; (*). marking the region of breaking of an arch; *u*, u^1. arches; *w.* wood of host into two; other letterings as in fig. 3. As the figure is diagrammatic no guarantee of proportions of different parts is given. FIG. 5. slightly older seedling; note the later formed leaves are alternately arranged. FIG. 6. oblique section through the seedling; *l.* leaf; other letterings as in Fig. 3. X 28. FIG. 7. t. s. slightly older plumule × 28.

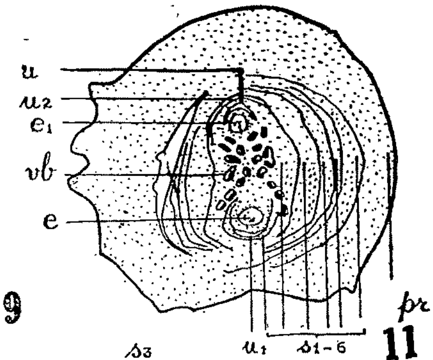
the study of serial longitudinal sections through both planes.



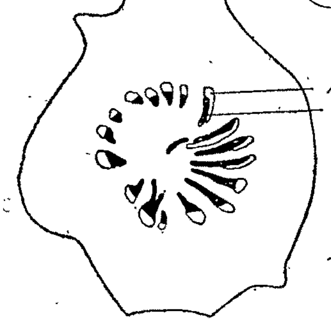
8



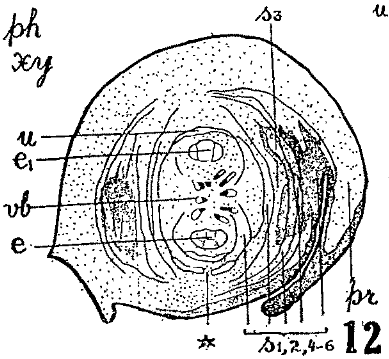
9



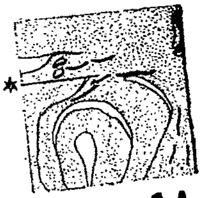
11



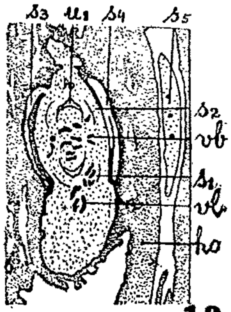
10



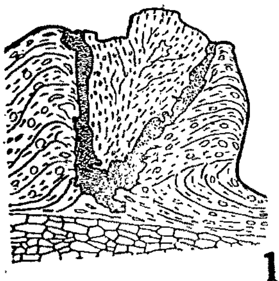
12



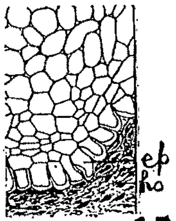
14



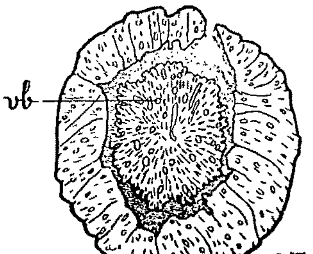
13



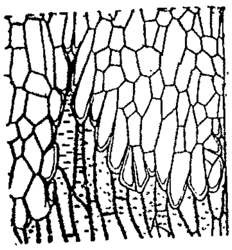
16



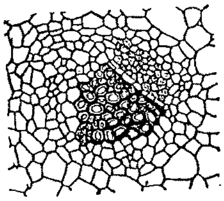
15



17



18



19

FIG. 8. l. s. tissue of holdfast; *c*. cortical cells; *ep*. epidermis; *ho*. degenerated host tissue in contact with the holdfast; *hy*. hypodermis × 650. FIG. 9. t. s. holdfast at level 9 in FIG. 3 × 28. FIG. 10. t. s. holdfast at level 10 in FIG. 3. note xylem processes(*xy*) jutting into pith; *ph*. phloem of some bundles flanking the xylem (*xy*) × 28. FIGS. 11, 12 and 13. t. s. haustorium at levels 11, 12 and

Thus Figs. 11 and 12 show the presence of two somewhat circular patches (e, e^1; also Fig. 4) of empty spaces formed by the breaking down of cells which enlarge considerably before dissolving. The development of these spaces can be compared to the method of formation of resin canals in *Nuytsia floribunda* (12), a tree of the Loranthaceae, growing in Australia as a root parasite. On the outside of the spaces, described above, are a number of arches of the same type. It is interesting to find that the arches which are nearest to the circular spaces are broad with short arms, while those that lie more to the exterior are narrower and their arms progressively longer, reaching nearer those of the opposite side (compare u with u^1, u^2 Fig. 11). The flattening of these arches is very likely an outcome of the pressure on them by the successively formed inner arches.

The circular spaces and arches are arranged at the drawn out ends of the compressed vascular supply of the haustorium.

The other prominent feature is the presence of a number of more or less concentric zones of crushed tissues separating broad parenchymatous sheaths (s_{1-6}) from the peripheral layers (*pr*) of the haustorium. These crushed areas always lie external to the flattened ring of vascular bundles, the empty spaces (e, e^1) and arches (u, u^1, u^2) described above. They are more prominent in the direction of the long axis of the infected branch. In longitudinal sections of the haustorium, transverse to the host, the parenchymatous sheaths run obliquely in the host tissue.

Cross sections of the haustorium taken at lower levels show that the arms of opposite arches extend and join each other. The extension of the arms of these arches is brought about by cells, lying in the region of extension, degenerating and appearing crushed.

13 in the text Fig. 3; e & e^1 empty spaces; *ho.* host; *pr.* peripheral sheath of haustorium; s_1-s_6, sheaths; u, u^1, u^2, arches; v. b. vascular bundles; (*) marking place of breaking of an arch; for furher explanation see text. × 28. FIG. 14 tangential l. s. part of the haustorium transverse to the host; note the method by which the inner tissue of the haustorium becomes continuous with the peripheral layers forming sheaths; the place of continuity shown by an asterisk (*). × 110. FIG. 15. small portion of a sheath to show the glandular nature of the epidermal cells (*ep*); host tissue (*ho*) in an advanced state of degeneration × 650. FIG. 16. l. s. burr showing radial l. s. of somewhat conical haustorium (prepared after grinding technique). × 5. FIG. 17. t. s. old haustorium surrounded by host burr; *v. b.*, the branches from the central vascular supply fan out into the parenchymatous outer zone of the haustorium in contact with the host burr (prepared after grinding). × 5. FIG. 18. l. s. slightly older haustorial tissue in intimate contact with host wood; note the glandular nature of the layer of haustorial cells in contact with the host wood. × 650. FIG. 19. t. s. vascular bundle in the cortical region of the haustorium. × 287.

Simultaneously with the arms of arches of the opposite side joining, the arches break from the middle (Figs. 12, 14); allowing the inner tissue of the haustorium to become continuous with the outer tissue. Traces from the main vascular cylindrical pass out into a sheath through this region which is marked with asterisk.

Transverse sections of the extreme tip of the haustorium also show only collateral and endarch vascular bundles (Fig. 13) but the sheaths (s_1-s_6) in this region are broader and have further spread along the long direction of the branch of the host. The broadening of the sheaths is due to laterally formed vigorous cambium inside their bodies. The epidermal cells of sheaths also show active division and the resulting cells in contact with the host tissue are glandular in nature. (Fig. 15).

Small portions of detached host tissue embedded in the body of the haustorium can be made out at several places and have also been described by Tubeuf (25) and Heil (10) in *Viscum album* and *Struthanthus* species respectively. Both authors state that the intrusion of these masses of the host into the parasitic body is a clear indication of the reaction of host to the penetrating haustorium.

The whole of the haustorium of *D. falcata*, as the above account shows, is, much against expectation, a stem structure with sheaths of parenchyma enveloping on the outside and spreading into the tissue of the host. A number of stone cells appear in the sheaths as they grow slightly older. Soon however the identity of the sheaths becomes obscure.

It is difficult to assign a definite morphology to these sheaths until a large number of haustoria of several Loranthaceae have been worked out.

OLD HAUSTORIUM

Longitudinal sections of old "burrs" of hosts carrying the parasitic haustorium show that it is roughly cone-shaped (Fig. 16). The sheaths described in connection with the younger haustorium are not distinguishable in older haustoria. The vascular supply of haustorium at this age shows a considerable amount of secondary growth (Figs. 16 &17) and phloem in most cases is crushed beyond recognition. The part of the haustorial cone, which is in intimate contact with the wood of the host, is formed of parenchymatous cells (Fig. 18). An appreciable number of strands from the main vascular supply of the haustorium, are seen to be growing out in its parenchyma. Most of these branches, however, stop short of the peripheral zone of parenchyma of the main haustorium. In a few cases only, a vascular strand from the haustorium was even found to have entered a few millimetres into the wood of the host.

The structure of these vascular bundles is not very clear in sections prepared by grinding technique; but they appear to be collateral (Fig. 19).

Loranthus aphyllus described by Thiselton-Dyer (23, p. 756; also his plate xi, figs. 5 and 6) shows a collateral bundle coming off from the main vascular tissue of the haustorium. Thiselton-Dyer states about one of the vascular bundles, which was larger than the rest "had an arrangement of its elements suggesting a collateral bundle." In *D. falcata* these collateral bundles are enclosed in a tissue of parenchyma from their origin and therefore run intra-cortically for an appreciable length.

LIST OF NEW HOSTS OF *Dendrophoe falcata* (L. F.) ETTINGS.

Name of host	Type of infection	Economic use
1. *Acacia catechu*	H.	Catechu extracted for use in betel.
2. *Aegle marmelos*	M.	Fruit
3. *Achras sapota*	V. H.	Fruit
4. *Bassia latifolia*	S.	Timber and economic
5. *Bauhinia variegata*	M.	Economic and ornamental
6. *Bridelia retusa*	M.	Economic
7. *Buchanania latifolia*	M.	Fruit
8. *Callistemon lanceolatum*	S.	Ornamental
9. *Cassia fistula*	H.	Ornamental & Medicinal
10. *Casuarina cunninghami*	S.	Ornamental & fuel
11. *Citrus medica* (several varietes)	S.	Fruit
12. *Duranta plumieri*	S.	Ornamental
13. *Eleodendron glaucum*	M.	Timber
14. *Eriobotrya japonica*	S.	Fruit
15. *Eugenia jambos*	S.	Fruit
16. *Eucalyptus robusta*	M.	Ornamental
17. *Ficus glomerata*	H.	Timber and fruit
18. *Ficus religiosa*	V. H.	Timber and fuel
19. *Garuga pinnata*	V. H.	Economic
20. *Gossypium arboreum*	S.	Economic
21. *Grevillea robusta*	H.	Ornamental
22. *Grewia asiatica*	H.	Economic
23. *Heritiera fomes*	M.	Economic
24. *Lagerstroemia flos-reginae*	H.	Fruit and timber

Name of host	Type of Infection	Economic use
25. *Mimusops elengi*	H.	Ornamental and Fruit
26. *Mimosa pudica*	S.	Ornamental
27. *Pinus longifolia*	S.	Timber
28. *Premna latifolia*	H.	Economic
29. *Prosopis juliflora*	V. H.	Fuel
30. *Pyrus communis*	M.	Fruit
31. *Shorea robusta*	H.	Timber
32. *Swietenia macrophylla*	S.	Timber
33. *Taxodium distichum*	S.	Ornamental
34. *Wrightia mollissima*	H.	Economic

Abbreviations: H, heavy; M, moderate; S, slight; and V. H., very heavy infections.

This paper is based on research carried out in 1936-37 at the University of Lucknow under the supervision of the late Professor B. Sahni, for whose guidance I wish to express my sincere appreciation. It was not until my visit to the Botany School, Cambridge, in 1951, through the kind permission of Professor G. Briggs, that I was able to prepare the results for publication. I have to express my gratitude to Mr. E. J. H. Corner for advice and criticism during this preparation.

SUMMARY

1. *Dendrophthoe falcata* attacks only dicotyledonous plants and gymnosperms. It occurs in India on 191 hosts, of which 34 are reported here for the first time.
2. The mature embryo possesses two cotyledons which are distally fused and give the embryo a monocotyledonous appearance.
3. There are seven to thirteen endarch vascular bundles in the plumule.
4. The hold-fast is an irregularly swollen pad, formed at the radicle end of the seedling, pressed against the bark of the host and formed of endarch collateral vascular bundles arranged in a ring round a wide pith.
5. The anatomy of the haustorium shows it to be, rather unexpectedly, a stem structure. Surrounding the central axis, which contains a flattened ring of collateral, open, and endarch vascular bundles with practically no pith, there are a number of concentric parenchymatous sheaths with an uncertain morphology; these sheaths arise from two regions of the cortex, one at each end of the flattened ring of vascular bundles.

LITERATURE

1. Arens, F. 1911. *Loranthus sphaerocarpus* auf *Dracaena* spec. Ein Fall des Parasitierens einer Loranthacee auf einer Monokotyle. Zugleich ein Beitrag zur näheren Kenntnis des Loranthaceen-Haustoriums (Inaug-Diss. Jena).

2. Bamber, C. J. 1916. Plants of the Punjab. Lahore.
3. Danser, B. H. 1929. On the taxonomy and the nomenclature of the Loranthaceae of Asia and Australia. *Bull. Jard. bot. Buitenz.*, **10** : 291-373.
4. Danser, B. H. 1931. The Loranthaceae of the Netherlands Indies. *Bull. Jard. bot. Buitenz.*, **11** : 233-519.
5. Danser, B. H. 1933. A new system for the genera of Loranthaceae; Loranthoideae, with nomenclature for the Old World species of this subfamily. *Verh. Akad. Wet. Amst.*, **29** : 1-128.
6. Engler, A., and Prantl, K. 1893. Die natürlichen Pflanzenfamilien, III. Teil Abeitlung 1, Leipzig.
7. Engler, A and Prantl, K. 1935. Die natürlichen Pflanzenfamilien, 2 Aug 1. Band *16b.* Leipzig.
8. Ezekiel, M. H. 1935. Double parasitism of *Loranthus* and *Viscum* on *Eugenia. Current Sci.*, **4** : 162.
9. Fischer, C. E. C. 1926. Loranthaceae of Southern India and their host plants. *Rec. bot. Surv. India,* **11** : 159-195.
10. Heil, H. 1926-27. Haustorialstudien an *Struthanthus*-Arten. *Flora* (N. F.) **21** : 40-76.
11. Heinricher, E. 1916. Über die geotropischen Reaktionen unserer Mistel (*Viscum album* L) *Ber. dtsch. bot. Ges.*, **34** : 818.
12. Herbert, D. A. 1920. The Western Australian Christmas Tree. *Nuytsia flosribunda* (The Christmas Tree)—its structure and Parasitism: *J. roy. Soc. W. Aust.*, **5** : 72-88.
13. Kaul, K. N. 1935. On a method of preparing large thin sections of plants by grinding. *Curr. Sci.*, **4** : 99-102.
14. Metcalfe, C. R. and Chalk, L. 1950. Anatomy of the Dicotyledons. Vol. I and II. Oxford 1950.
15. McLuckie, J. 1923. Studies in parasitism. A contribution to the physiology of the Loranthaceae of New-South Wales. *Bot. Gaz.*, **75** : 333-369.
16. Ridley, H. N. 1930. The Dispersal of Plants throughout the World. Ashworth.
17. Sayeed-ud-Din, M. and Salam, M. A. 1935. A somewhat cosmopolitan parasite. *Curr. Sci.*, **4** : 160-162.
18. Singh, B. 1952. A contribution to the floral morphology and embryology of *Dendrophthoe falcata* (L. f.) Ettings. *J. Linn. Soc.*, (Bot.) **53** : 449-473.
19. Skene, M. 1924. The biology of the flowering plants. London.
20. Solereder, H. 1908. Systematic Anatomy of the Dicotyledons (Translated by L. H. Boodle, and F. E. Fritsch). Oxford.
21. Srivastava, G. D. 1935. Two new host plants of *Loranthus* at Allahabad. *Curr. sci.*, **4** : 106-107.
22. Stevenson, G. B. 1934. The life history of the New Zealand species of the parasitic genus *Korthalsella. Trans. Roy. Soc. New-Zealand,* **64** : 175-190.
23. Thiselton-Dyer, W. T. 1901. Morphological notes IV. The haustorium of *Loranthus aphyllus Ann. Bot.*, **15** : 749-757.
24. Thoday, D. 1951. The Haustorial System of *Viscum album. J. expt. Bot.*, **2** : 1-19.
25. Tubeuf, K. V. 1923. Monographie der Mistel. Munchen und Berlin.

EFFECT OF CERTAIN SYNTHETIC GROWTH REGULATORS ON THE FORM OF LEAF OF *BRASSICA CAMPESTRIS* LINN. AND *LENS ESCULENTA* MOENCH

By V. N. Krishna Pillai, M. Sc. and S. C. Chakravarti, M. Sc., Ph. D., *Department of Botany, B. R. College, Agra.*

Introduction

Modifications of organs in plants under the influence of certain auxins and their antagonists have been reported by a number of workers (1-6, 8, 9-11). Of these 2,4-dichlorophenoxyacetic acid and 2,3,5-tri-iodobenzoic acid have been found to produce various degrees of fusion of the foliage. In corn and oats 2,4-dichlorophenoxyacetic acid gave rise to "onion leaves" (1). In cotton, the terminal buds of seedlings raised from seeds treated with this chemical, were found to be encased in a foliar tube (6). Coalescence of leaves in flax under similar treatments have also been recorded by Tandon (9).

Application of 2,3,5-tri-iodobenzoic acid to the soil resulted in the failure of the leaves of tomato to separate from each other, forming large modified organs or cups (11). One of the most interesting cases of leaf-deformity under the influence of this chemical has been reported by Harder and Opperman in *Kalanchoë blossfeldiana*, the terminal shoots of which generally ended in a cup-shaped-formation and the first leaf on the lateral shoot also gave rise to similar structures.

Wenck (10), while working on *Codiaeum variegatum* f. *inturruptum* and f. *pictum*, *Bryophyllum proliferum* and *Pisum sativum*, found beta-indoleacetic acid, alpha-naphthaleneacetic acid, 2,4-dichlorophenoxyacetic acid and coumarin to be generally without effect, whereas, 2,3,5-tri-iodobenzoic acid resulted in petiole and leaf coalescence in *C. v. f. pictum* and curvature of the blade and simplification of leaflets in *B. proliferum.* Thus it would be seen that though 2,4-dichlorophenoxyacetic acid and 2,3,5-tri-iodobenzoic acid have similar formative effect on different plants, their action on the same plant might be dissimilar. An extension of our observations with these and other hormones and anti-hormones, to new species is likely to be of interest.

MATERIAL AND METHODS

The experiments were carried out with *Brassica campestris* Linn., strain T. 10 S. 13 and *Lens esculenta* Moench, strain Ample. Chemicals used are: indolylacetic acid (IAA), indolylbutyric acid (IBA), a-naphthaleneacetic acid (NAA), 2,4-dichlorophenoxyacetic acid (2,4-D), 2,3,5-tri-iodobenzoic acid (TIBA), maleic hydrazide 40 (MH) and coumarin. The first five chemicals were used in concentrations of 500, 50, 5, 0.5, 0.05 and 0.005 parts per million and the last two of 0.2 and 0.04 per cent in distilled water. The hormones and antihormones were applied to mustard by (i) soaking the sprouted seeds for a period of four hours and (ii) spraying, to run off the leaves of the plants at the third leaf-stage daily, for a period of one week, and to *Lens* by the first method only. Effect of all the above mentioned chemicals were determined on mustard, while on *Lens* MH and coumarin were not used.

OBSERVATIONS

Mustard: Of all the treatments, only soaking of seeds in TIBA and 2,4-D, shows some effect on leaf-forms. Normal leaves are shown in fig. 1 and the modified ones in figs. 2 and 3 (Plate XI), in which there are different degrees of coalescence of leaves. The midribs divide at various distances and end in two or three tips. In a number of cases the leaves remain separated almost the whole of their lengths, and unite only at the base. More interesting results are seen in seedlings raised from seeds treated with higher concentrations, *i. e.*, 50 and 5 p. p. m. of 2,4-D and 500 and 50 p. p. m. of TIBA; here the laminae of the first and second or the second and third leaves are fused to form ascidia-like structures (fig. 4, Plate XI), while the petiolar portions are developed into a more or less solid cylinder which completely encloses the shoot apices. This cylinder is, however, ruptured at the base by the subsequent growth of the shoot apex much like the extravaginal shoots of grasses (fig. 1, Plate XII).

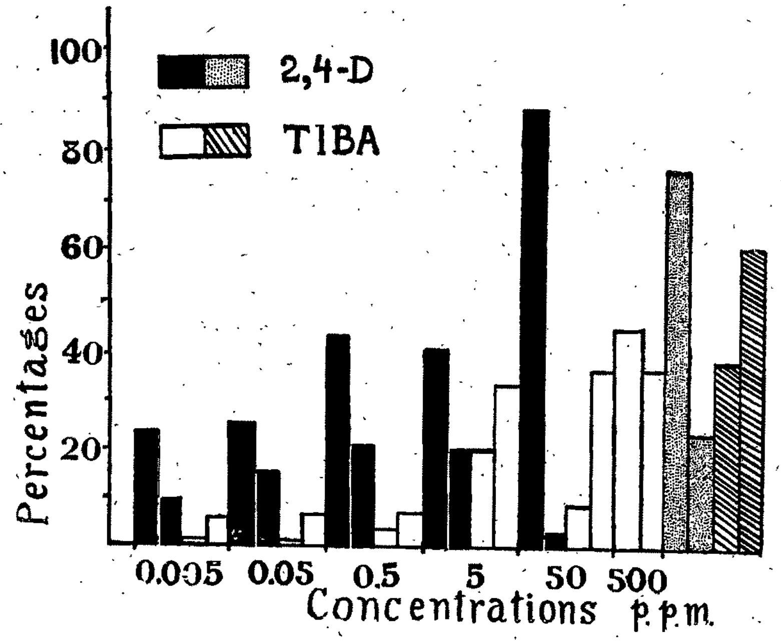
The two chemicals, 2,4-D and TIBA, however, differ in their effect with regards to the position of the deformed leaves on the stem. For each concentration, plants raised from 2,4-D treated seeds are found to have majority of their deformed leaves at the first node above that of the cotyledons, while in plants raised from TIBA treated seeds this occurs in the next higher one (Table I; text-fig. 1). Percentages of plants with leaf-deformities are proportional to the concentration of the chemicals and for the same strength 2,4-D possesses greater formative effects than TIBA (Table I; text-fig. 2).

TABLE I

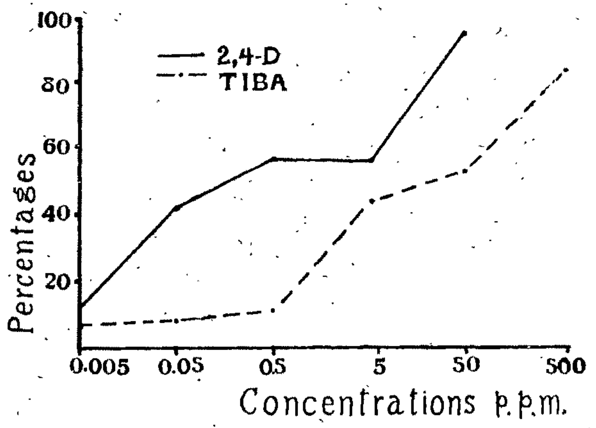
Showing comparative effects of 2,4-D and TIBA treatments on leaf-deformities in mustard.

Chemicals	Conc. p. p. m.	Total No. of plants	Plants with deformed leaves		Position of deformed leaves: At the first node		At the second node	
			No.	Percentage	No.	Percentage	No.	Percentage
2, 4-D	500	A few seeds germinated but failed to grow.						
,,	50	73	67	91.8	65	89.0	2	2.7
,,	5	80	43	53.8	34	39.1	9	103
,,	0.5	81	45	55.6	30	42.2	15	21.1
,,	.05	80	33	41.3	20	25.0	13	15.35
,,	.005	79	9	11.4	2	22.5	7	8.9
Total	——	393	197	50.1	151	76.9	46	23.3
TIBA	500	78	63	80.8	35	44.9	28	35.9
,,	50	61	31	50.8	9	14.8	22	36.1
,,	5	77	33	42.9	8	10.4	25	32.5
,,	0.5	83	9	10.8	3	3.6	6	7.2
,,	.05	74	6	8.1	1	1.3	5	6.5
,,	.005	71	5	7.0	1	1.4	4	5.6
Total	——	444	147	33.3	57	38.7	90	61.2

Lens: Leaf-deformities are observed only in treatments with TIBA solutions of 500 p. p. m. strength. Most common modification consists of the condensation of the rachis and partial to complete fusion of the leaflet-margins, giving the leaf a palmate appearance (figs. 8, 9, Plate XI and fig. 2, Plate XII). In a few cases, however, ascidia are also formed, while modification of individual leaflets into ascicular forms is also met with (figs. 10, 11, Plate XI).



TEXT-FIG. 1. Shows the percentages of plants bearing deformed leaves at the node just above the cotyledonary one and the next higher (first and second bar of each pair respectively), under the influence of different concentrations of 2, 4-D and TIBA. Last two pairs of bars are for percentage totals.



TEXT-FIG. 2. Shows the percentages of plants, raised from seeds treated with different concentrations of 2, 4-D and TIBA, having leaf-deformity.

DISCUSSION

2,4-D is an auxin and TIBA an auxin antagonist (2). It is interesting that in spite of their diverse behaviour on cell elongation, they modify the leaves of mustard in a similar way. The data on *Lens*, however, appear to show that the action of these two chemicals is specific.

Gifford (3) treated the fully expanded cotyledons of cotton seedlings with 2,4-D and observed deformities in subsequently developed leaves. Leaves most severely distorted varied from the second to the fifth. Some effects were recorded even upto the tenth one. From these observations, Gifford concluded that the effect of 2,4-D persists in the apical meristem. In a recent communication McIlrath and Ergle (5) reported the development of as many as 24 malformed leaves on the same plant after 2,4-D treatment was over. In the present investigation, however, no such persistence of 2,4-D effect could be detected in any of the methods of application. In view of the fact that a greater percentage of modifications were present in an upper node in the seedlings of mustard raised from TIBA treated seeds, the action of this chemical, has thus started later and persisted longer in the apical meristem of mustard than that of 2,4-D.

Fusion of leaves in nature is not an uncommon phenomenon. Rao (7), while reporting a case in *Tabernaemontana coronaria*, has reviewed the existing literature. It would be of great interest to know whether there is any relationship between the natural hormone content of the shoots of such plants and leaf-deformities. McIlrath and Ergle (5) demonstrated that the long persistence of 2,4-D effect in cotton plants is due to a continuous liberation of a hormone-like substance from the shoot-tip. This observation, however, goes to show that a study of plants showing coalescence of leaves in nature on the lines suggested above, might be fruitful.

SUMMARY

1. The present investigation was undertaken to determine the effects of IAA, IBA, NAA, 2,4-D, TIBA, MH and coumarin on the leaf-form of *Brassica campestris* Linn. and *Lens esculenta* Moench.

2. Soaking of seeds with higher concentrations of 2, 4-D and TIBA only, produced various degrees of coalescence of leaves in mustard leading to the formation of ascidia. In *Lens* TIBA alone is found to be effective. The most common modifications in this plant consist of condensation of the rachis and coalescence

of leaflets so as to render the leaf palmate. There are a few cases of ascidia formation and modifications of individual leaflets into needle-shaped structures.

3. In mustard, TIBA treatments result in leaf-deformities at a higher node than what are found through an application of 2,4-D, indicating thereby, that the effect of the former chemical starts later and persists longer than that of 2, 4-D in the apical meristem of mustard.

REFERENCES

1. DUNHAM, R. S. 1951. Differential responses in crop plants. Plant growth substances. Edited by Skoog, F., p. 195. Univ. of Wisconsin Press.
2. GALSTON, A. W. 1947. The effect of 2,3,5-tri-iodobenzoic acid on growth and flowering of soybeans. *Amer. J. Bot.*, **34** : 356.
3. GIFFORD, E. M., Jr. 1953. Effect of 2,4-D upon the development of the cotton leaf. *Hilgardia*, **21** : 607.
4. HARDER, R. and OPPERMAN, A. 1952. Einfluss von 2, 3, 5-Trijodbenzoesäure auf die Blütenbildung und die vegetative Gestaltung von *Kalanchoë blossfeldiana*. *Planta*, **41** : 1.
5. MCILRATH, W. J. and ERGLE, D. R. 1953. Further evidence of persistence of 2,4-D stimulus in cotton. *Plant Physiol.*, **28** : 693.
6. MCILRATH, W. J., ERGLE, D. R. and A. A. DUNLAP. 1951. Persistence of 2,4-D stimulus in cotton plants with reference to its transmission to the seed. *Bot. Gaz.*, **112** : 511.
7. RAO, L. N. 1937. A note on the variation in leaf form and ascidia formation in *Tabernaemontana coronaria* R. B. *J. Indian Bot. Soc.*, **16** : 227.
8. SEN, B. and JOSHI, H. C. 1954. Effect of 2,4-Dichlorophenoxyacetic acid on the growth of mustard T. 102. *Proc. Indian Sci. Congress*, **3** : 157.
9. TANDON, R. K. 1949. The response of flax to rates and formulations of 2,4-Dichlorophenoxyacetic acid. *Agron. J.* **41** : 213.
10. WENCK, U. 1952. Die Wirkung von Wuchs— und Hemmstoffen auf die Blattform. *Zeitschr. Bot.*, **40** : 33.
11. ZIMMERMAN, P. W. and HITCHCOCK, A. E. 1942. Flowering habit and correlation of organs modified by tri-iodobenzoic acid. *Contr. Boyce Thompson Inst.*, **12** : 491.

Plate XI

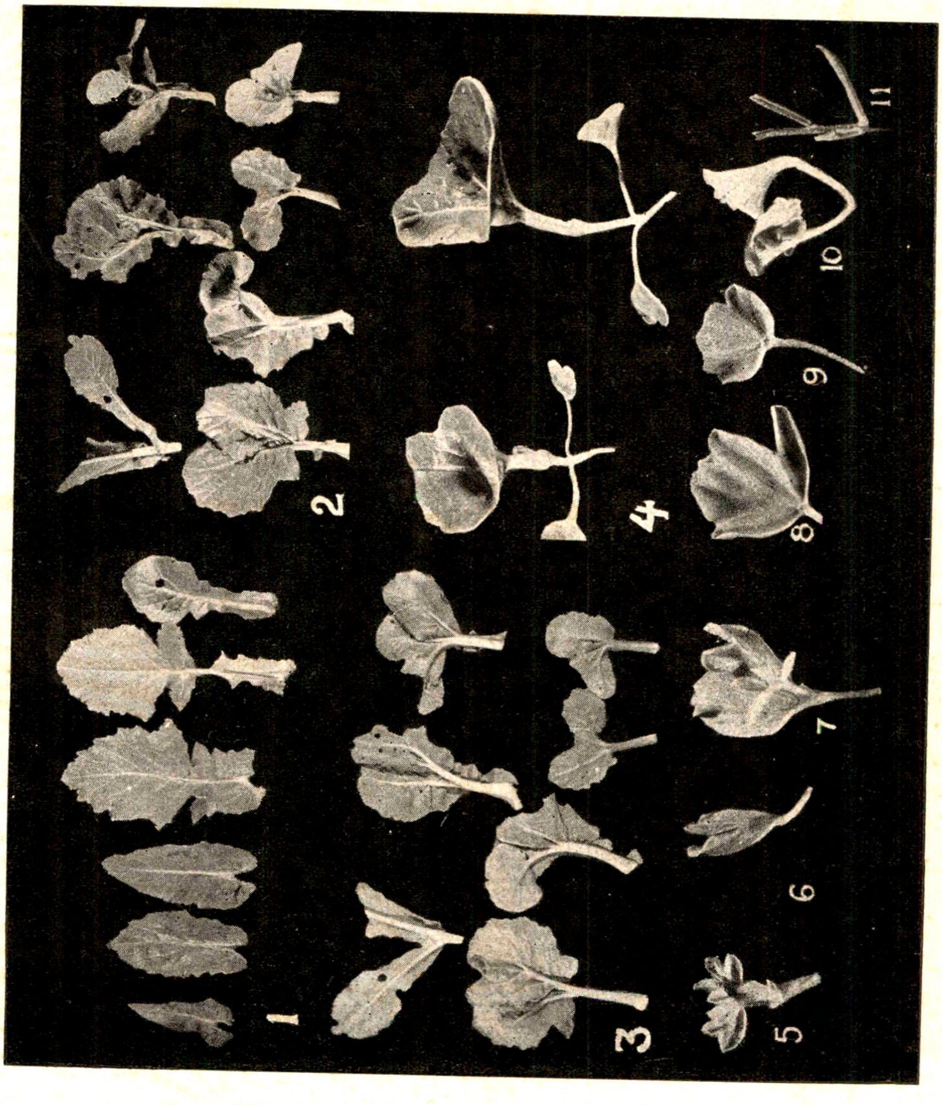
Fig. 1. Natural variations in the form of leaf of *Brassica campestris* L. Uppermost on the extreme left.

Fig. 2 & 3. Various degrees of coalescence of leaves found on mustard plants raised from seeds treated with 2,4-D and TIBA.

Fig. 2. Upper surface; Fig. 3. Lower surface.

Fig. 4. Extreme cases of coalescence of leaves leading to the formation of ascidia in mustard plants raised from seeds treated with 2,4-D and TIBA.

Fig. 5-11. Different types of modified leaves found on the plants of *Lens esculenta* Moench raised from seeds treated with TIBA

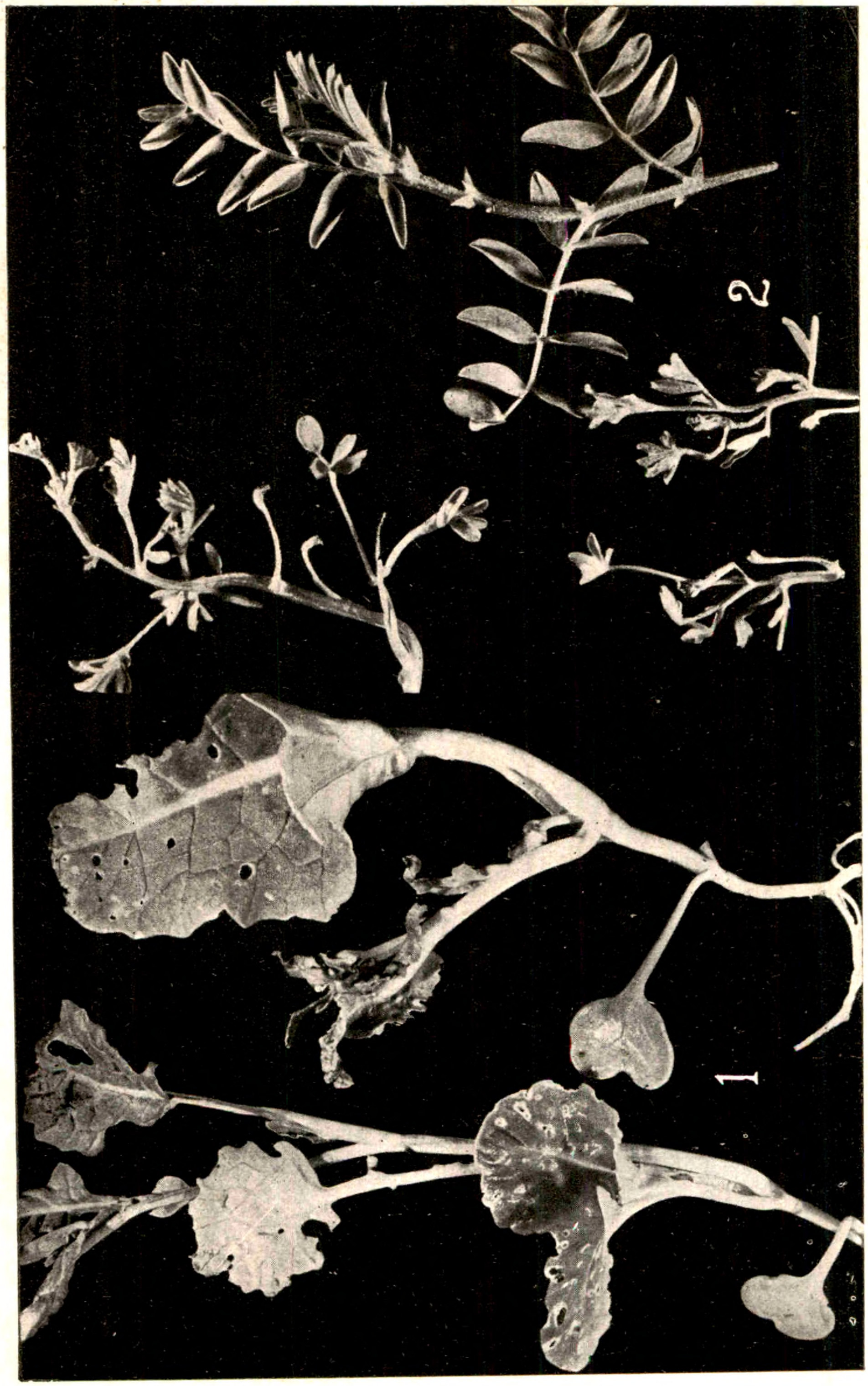


Pillai & Chakravarti : Growth Regulators

Plate XII

Fig. 1. Two plants of mustard with ascidia showing that the shoots come out by breaking through the petiolar cylinder.

Fig. 2. Left three; plants raised from TIBA treated seeds of *Lens esculenta* Moench showing modified leaves. Right; one branch from a normal plant of the same.



Pillai & Chakravarti : Growth Regulators

MORPHOLOGICAL STUDIES IN *MORUS* SPP.

By SATYA PAL SINGH, *Department of Botany, B. R. College, Agra, India.*

Morus has some historical importance on account of the fact that Camerarius in 1694, for the first time, demonstrated in this genus the phenomenon of sexuality. He pointed out that pollination was necessary for the development of viable seeds, and in case where no pollen grains were allowed to fall on the female flowers, abortive seeds were produced. In spite of such an important discovery made on this plant, a detailed embryological study is still lacking.

Based upon the observations of Hofmeister, Modilwesky and Tahara, Schnarf (26) mentions normal type of embryo sac development and free nuclear type of endosperm formation in *Morus*. Buonocore (3) has described the floral development in *M. alba*. No work, however, has been done on the embryo development and the seed structure. With a view to make a detailed study of the embryological stages and the development of the flower, the fruit and the seed of this genus, the present piece of investigation has been undertaken. The species worked upon are *M. indica* and *M. alba*.

MATERIAL AND METHOD

Female inflorescences of cultivated variety of *M. alba* were collected from the Botanical Gardens, B. R. College, Agra, and were fixed in formalin-acetic-alcohol. The flowers of *M. indica* and wild variety of *M. alba* were collected at Dehra Dun. The material was dehydrated through normal butyl-alcohol, tertiary butyl-alcohol and alcohol-xylol series. The last series proved better for the younger stages and the tertiary butyl-alcohol for the older ones. Embedding was done as usual in paraffin. Sections, ranging from 5 μ to 15 μ thick were cut according to the stage of the material. The stains used were iron-alum-haematoxylin, safranin-fast-green and crystal-violet-erythrosin.

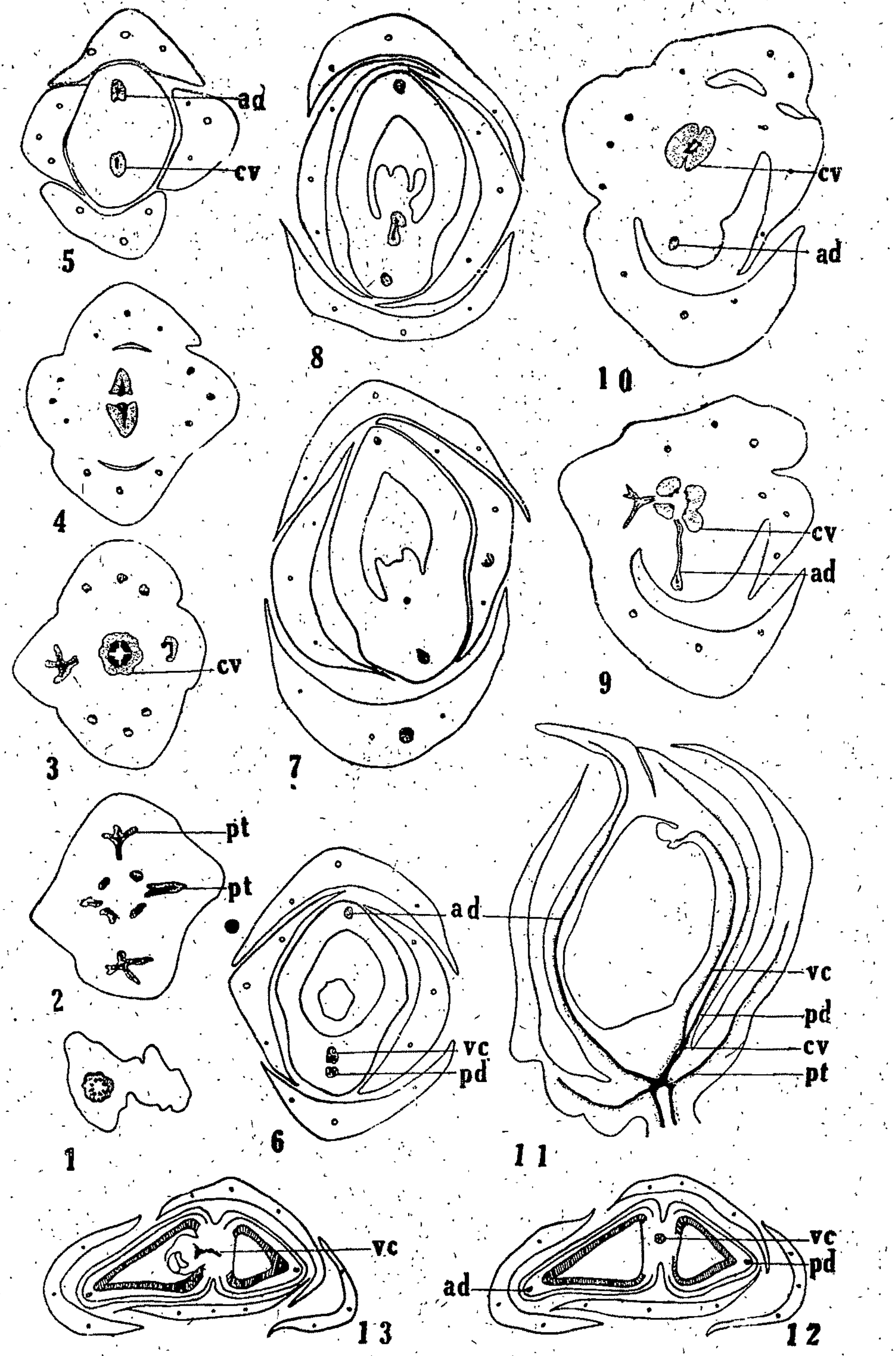
MORPHOLOGY OF THE FLOWER

Species of *Morus* are either monoecious or dioecious. *M. indica* and wild variety of *M. alba* have male and female flowers on different inflorescences but in the latter case, occasionally both male and female flowers occur on the same inflorescence. The cultivated seedless variety of *M. alba* shows more or less a dioecious nature. In Agra almost every inflorescence of the cultivated variety of *M. alba*, was observed to bear female flowers only. Roxburgh (25), too, described *M. alba* as dioecious. No perfect male flowers could be found locally. In extremely rare cases only, a few male flowers arise on the female inflorescence but whether or not they develop to form mature pollen grains is uncertain, as degeneration of the sporogenous tissue in such male flowers is commonly observed. Such a degeneration of the sporogenous tissue is also not uncommon in the anthers of the male flowers of *M. indica* and wild variety of *M. alba*. Sporadic cases of small portions of the ovary wall especially near the stigmatic end developed microsporangia. Recently, Pande and Shukla (22), too, have reported this in *M. alba*.

The male flowers are stalked. Each flower is formed of four free perianth leaves with imbricate aestivation and four stamens arise opposite to them. Female flowers are sessile. Each flower consists of four imbricate perianth leaves surrounding a pistil. The pistil is monocarpellary and has a superior unilocular ovary bearing a marginal, bitegmic and anatropous ovule. The stigma is bifurcated. Abnormally, female flowers of *M. alba* showed bilocular ovaries. Such teratological cases of bilocular ovaries have been recorded previously in *M. alba* by Buonocore (3) and in *M. nigra* by Welsford and Benson (29). The vascular supply to the carpels of these flowers is interesting because when compared with unilocular cases, it reveals the real nature of the gynaecium in *Morus*.

VASCULAR SUPPLY OF THE FEMALE FLOWER

Transverse section of the pedicel of the female flower of *M. alba* as well as of *M. indica* shows a complete ring of about



Text Figs. 1-13. Vascular supply of the female flower. *ad.*, anterior dorsal carpellary trace; *cv.*, vascular bundles left after the departure of the perianth traces; *pd.*, posterior dorsal carpellary

8 collateral and endarch vascular bundles (Fig. 1). In the region of the perianth, two opposite and decussate sets of vascular traces arise forming four gaps in the central stele (Fig. 2). Each of these vascular traces, divide into three, a median and two laterals for each perianth. The four bundles lying in the centre reorganise into a cylinder again (Fig. 3). In a perfectly median section the ring is seen to bifurcate in the anterio-posterior direction while ascending (Fig. 4). The vascular segment of the posterior side (cv) becomes amphicribral slightly higher up (Fig. 5). This is better understood in slightly oblique sections of another flower, where a trace arising in the anterior direction forms the dorsal vascular trace of the anterior carpel and the rest of the tissue moves as a ring in the posterior direction (Figs. 9, 10). The bundle of the anterior side ascends undivided and ends into the style (Figs. 6, 11), while the amphicribral bundle of the posterior side divides into two (Figs. 6, 7, 11). The inner branch enters the ovule as the ventral carpellary trace while the outer one passes up and ends in the style as the dorsal carpellary bundle of the posterior carpel (Figs. 8, 11).

The above description does not, however, agree with that given by Bechtel (1) on *M. alba*. He mentions four separate strands in the pedicel from which four traces are given out in a decussate manner to four perianth leaves. After the departure of the perianth traces there again remain four strands, one in the anterior, one in the posterior and the other two in the lateral positions. The anterior and the posterior strands are considered to be the dorsal bundles of the two carpel. The two lateral strands approach each other towards the posterior side. As they ascend, they unite and pass into the ovule. Welsford and Benson (29) have observed in *M. nigra*, the ovular strands to receive connections from the anterior carpellary strand in the basal region of the ovary, but such connections could not be seen by Bechtel (1) in *M. alba* and *M. nigra* or by the author in *M. alba* and *M. indica*.

trace; *pt.*, perianth trace; *vc.*, ventral carpellary trace. Figs. 1-8. T. S. of unilocular female flower from the pedicel upwards. x 52. Figs. 9, 10. T. S. (slightly oblique) of another female flower. Fig. 9. shows the origin of *ad* from *cv.* x 41. Fig. 10. shows *cv* moving towards the posterior direction as a single ring of vascular bundles. x 41 Fig. 11. L. S. showing the longitudinal course of the vascular bundles in a female flower with unilocular ovary. Note the division of *cv* into *vc* and *pd* x 15. Figs. 12, 13. T. S. female flower with bilocular ovary. Note the single median *vc* and two dorsals *ad* and *pd*. x 26.

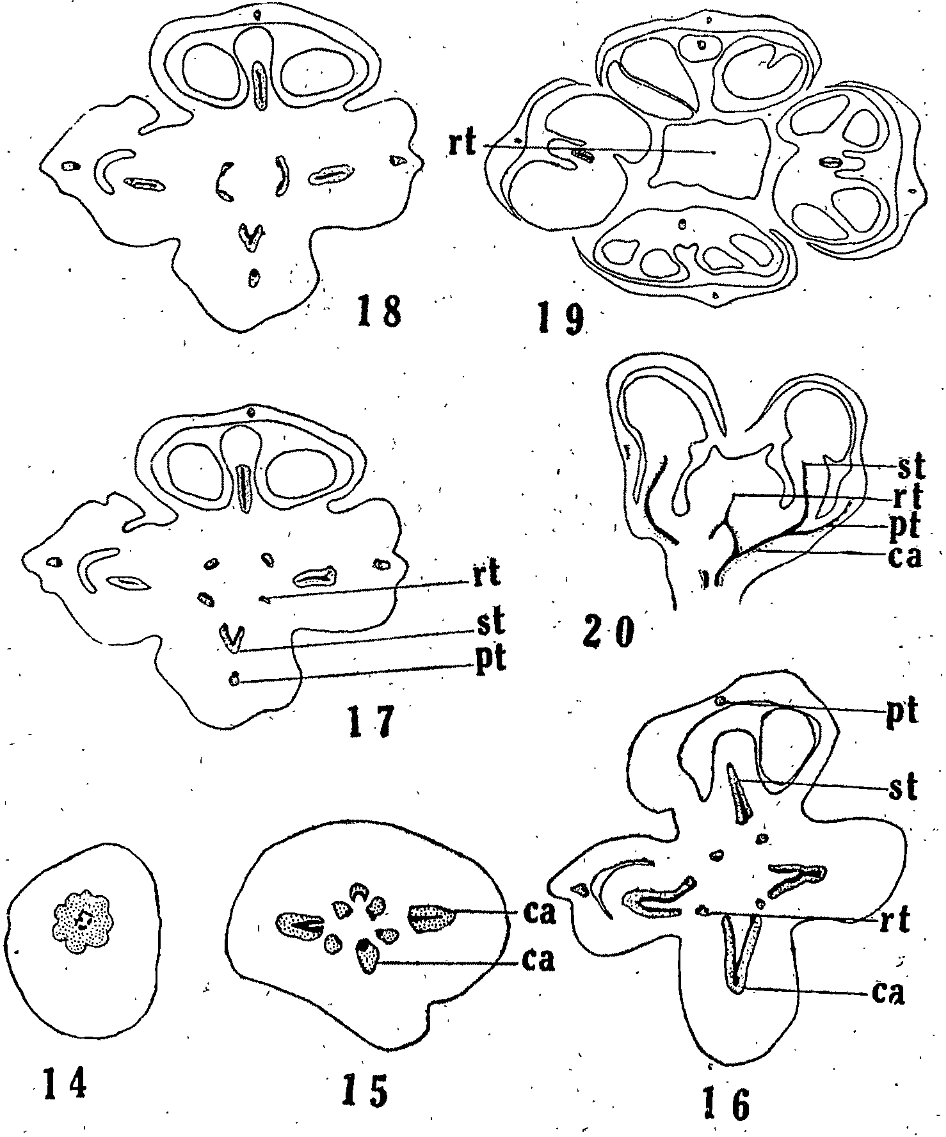
As described above there are a few flowers of *M. alba* with bilocular ovaries. The vascular supply of these consists of two dorsals and a central bundle as the ventral carpellary supply (Figs. 12, 13).

Since long the gynaecium in *Morus* has been considered to be bicarpellary (1, 2, 3). Bechtel (1) supports this view on the basis of the floral anatomy of the normal flowers of *M. alba*. Buonocore (3) derives the evidences from the developmental study of the normal, unilocular and abnormal, bilocular female flowers. He mentions that of the two carpels present originally, only one develops regularly giving rise to a unilocular ovary with one ovule. The other carpel, found to be much reduced from the beginning and fused with larger one along its margin, gives rise to one of the two stigmas of the ovary. In teratological cases both ovaries were observed to be more or less developed.

The anatomy of the flower with bilocular ovary described by me lends a convincing support to this view and explains clearly how by reduction in the carpels and fusion of the vascular bundles the unilocular condition has been attained in the normal flower. In the flower with unilocular ovary the posterior carpel has lost its cavity and consequently its ovule. Due to this reduction the central septum having the ventral carpellary strand has fused with the dorsal side of the posterior carpel. This has resulted in the fusion of the dorsal carpellary trace of the posterior carpel with the ventral carpellary trace forming an amphicribral bundle in the basal region of the ovary. It is, thus, important to find the anterior carpel fertile, bearing an ovule.

The change from the axile placentation to the marginal one in this case, supports the derivation of the marginal from the axile. It gives support to the primitiveness of the latter as envisaged by Puri (23). Chapman (6) likewise, in certain species of Berberidaceae, has observed the solidification of two of the three carpels, on account of which the axile placental column has become pushed to one side of the ovary changing multilocular condition to unilocular one.

The study of the flower with bilocular ovaries in *M. alba* is a very good example to support the importance of the teratological studies and the evidences derived therefrom in the explanation of the morphological nature of the floral parts.

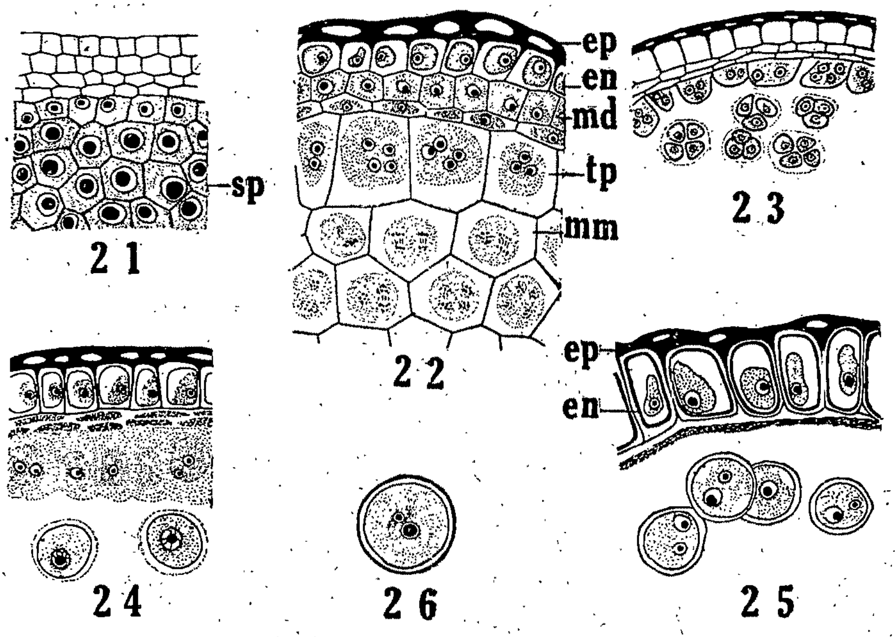


Text Figs. 14-20. Vascular supply of the male flower. *ca.*, common trace for perianth and stamen; *pt.*, perianth trace; *rt.*, residual vascular tissue; *st.*, stamen trace. Figs. 14-19: T. S. male flower from the pedicel to the level of the anther. × 35. Fig. 20. L. S. male flower. Note *rt* in the dome shaped rudimentary pistil. × 73.

VASCULAR SUPPLY OF THE MALE FLOWER

The pedicel of the male flower, like that of female, also shows a complete ring of 8 vascular bundles (Fig. 14). Four

V-shaped common traces are given out from this ring in a decussate manner (Fig. 15). From the base of each V, which faces towards the outside, a trace is given out to supply the perianth (Figs. 16, 17), after which the arms of the V unite while ascending to enter the stamens (Figs. 17, 18). A very small amount of vascular tissue is still left in the central region and continues up to a short distance into a dome shaped structure representing the sterile pistil (Figs. 19, 20*rt.*). This trace has been considered by Bechtel (1) to be the dorsal carpellary bundle of the abortive pistil. It is quite interesting to find that the perianth traces of the male flowers enter these organs singly instead of three as in the female flowers. Bechtel (1) has pointed out that as the perianth lobes in the female flowers persist and form the fleshy portion of the fruit, they require a strong vascular supply. Since perianth leaves in the male flowers are required only up to the anthesis they may contain a weak vascular supply.



Text Figs. 21-26. Microsporogenesis and the male gametophyte. *en.*, endothecium; *ep.*, epidermis; *md.*, middle layers; *mm.*, microspore mother cell; *sp.*, sporogenous cells; *tp.*, tapetum. Fig. 21. T. S. young anther showing the wall layers and *sp.* × 566. Fig. 22. Clearly differenciated anther wall at the meiosis stage of *mm.* Note the highly cutinized *ep* and the multinucleate *tp.* × 633. Fig. 23. Anther wall and the microspore tetrads. × 500. Fig. 24. The same at microspore stage. × 566. Fig. 25. Anther wall and the binucleate pollen grains. × 566. Fig. 26. Bicelled pollen grain. × 633.

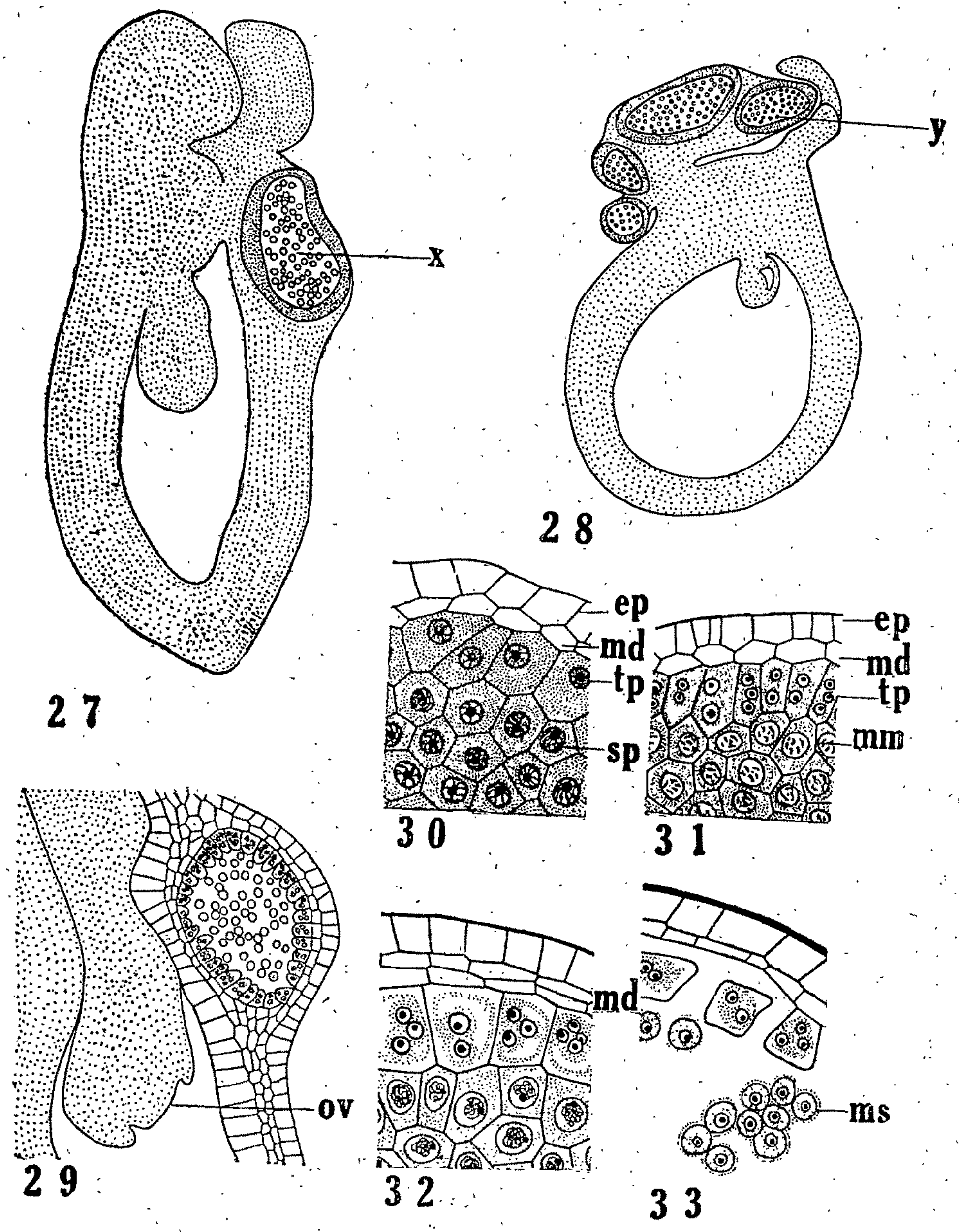
MICROSPOROGENESIS AND THE MALE GAMETOPHYTE

The anther wall consists of five layers, the epidermis, endothecium, two middle layers and a layer of tapetum (Fig. 21). The epidermal cells get tangentially elongated and their walls are cutinized during reduction division of microspore mother cells (Fig. 22). Cutinization of the epidermal cells is also reported in *Musa* (17), *Sesamum* (21), *Anona* (14), *Ipomoea* (15), *Ageneha* (16), *Melastoma* (27), *Oxyspora* (28). The cells of the middle layers also become tangentially elongated and start to degenerate at the time of meiotic division of the microspore mother cells and are completely absorbed by the time pollen grains become mature. Simultaneous with the start of the reduction division in the microspore mother cells, the tapetum becomes multinucleate; its cells start disorganizing and, at a stage when microspores become separate from their respective tetrads, the cell walls of tapetum have already disintegrated, so that it forms one continuous peripheral mass which is absorbed gradually, possibly, by the developing microspores.

The microspore mother cells show normal meiotic division (Fig. 22). Cytokinesis takes place simultaneously by the development of furrows forming tetrahedral and isobilateral groups of microspores (Fig. 23). Each microspore becomes spherical on separation (Fig. 24). Its nucleus divides giving rise to a vegetative and a generative nucleus (Fig. 25). The pollen grains are shed at the bicelled stage (Fig. 26), similar to *Holoptelia integrifolia* (4).

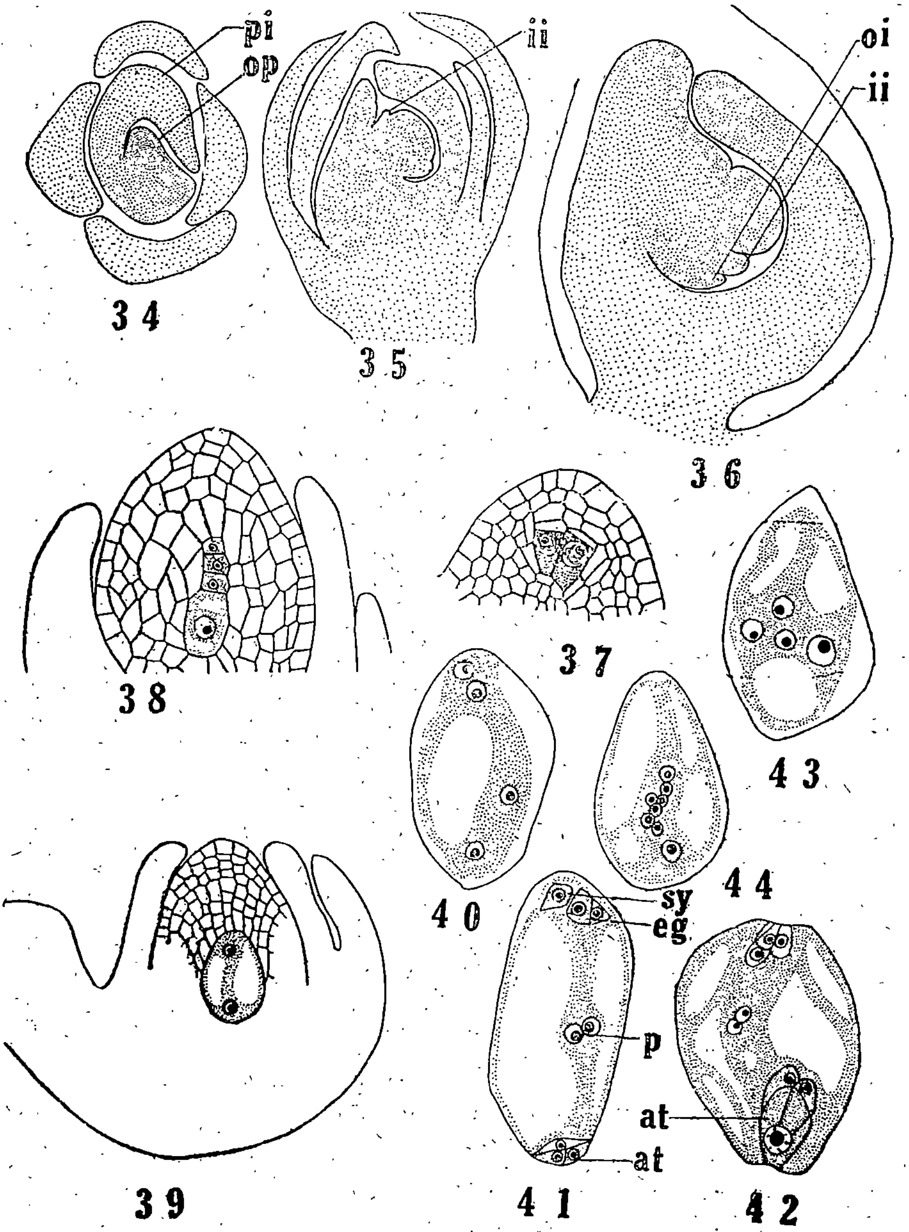
As pointed out before, in certain anther chambers all the sporogenous cells completely degenerate.

It is interesting to find a few cases in which microspores develop in the ovary wall below the stigma (Figs. 27, 28). The number of wall layers in these cases vary from three to four, including the tapetum and the epidermis (Figs. 29, 30, 31, 32). The development of the microspores takes place normally like those of the male flowers. There is, however, a marked difference in their size from that found in the normal cases (compare Fig. 33 with Fig. 24). Since no normal pollen grains are seen in any of these microsporangia it is doubtful if they ever develop to maturity.



Text Figs. 27-33. Ovarian microsporangia. *ep.*, epidermis; *md.*, middle layer; *ov.*, ovule; *sp.*, sporogenous cells; *tp.*, tapetum. Figs. 27, 28. show the site of the differenciation of the ovarian microsporangium marked x and y. × 100 and × 33 respectively. Fig. 29. shows the ovule and the microsporangium side by side. × 166. Fig. 30, T. S. of an young ovarian microsporangium showing *ep*, single *md*, *tp*, and *sp.*, × 500. Fig. 31. shows the multinucleate *tp* and *mm* in prophase. × 500 Fig. 32. Note the presence of two *md.* × 500. Fig. 33. A portion of y magnified × 566.

Such transformation of the carpellary tissue into microsporangia are also reported in *Salix* (5, 10), *Dianthus* (24), *Citrus* (9) and *Cuscuta* (13).



Text Figs. 34-44. Megasporogenesis and the female gametophyte in *M. alba* (Local cultivated variety). *at.*, antipodal cells; *eg.*, egg; *ii.*, inner integument; *oi.*, outer integument; *p.*, polar; *pi.*, pistil initial; *op.*, ovular primordium and *sy.*, synergids. Fig. 34. T. S. bud showing the differenciation of *op* from one of the flanks of *pi*. × 200. Fig. 35. L. S. bud showing the initiation of *ii*. × 23. Fig. 36. L. S. bud showing the initiation of *oi*. × 133. Fig. 37. Two megaspore

MEGASPOROGENESIS AND THE FEMALE GAMETOPHYTE

The primordium of the ovule arises on the posterior flank of the pistil initial (Fig. 34). The inner integument arises first (Fig. 35) and is soon followed by the outer integument (Fig. 36). The micropyle is formed of the inner integument.

The hypodermal layer at the tip of the nucellus becomes differenciated from the rest, to function as the archesporial tissue. Its cells develop denser cytoplasm and prominent nuclei. By the time inner integument differentiates, each archesporial cell shows a tangential division to give rise to a primary parietal cell and a sporogenous cell which functions directly as the megaspore mother cell (Fig. 37).

The primary parietal cells undergo both periclinal and anticlinal divisions forming an extensive tissue above the megaspore and its further developmental stages (Figs. 38, 39). All the megaspore mother cells degenerate except one which grows into a linear tetrad of megaspores. Only the chalazal megaspore of the tetrad develops further, the rest three degenerate (Fig. 38). The development of the embryo sac is of the Polygonum-type. Only a few embryo sacs reach the mature stage and most of them die either at the binucleate embryo sac stage or at any of the subsequent stages prior to maturation of the embryo sac. Both nuclei of the binucleate embryo sac occupy the poles as usual (Fig. 39) and develop further to give rise to a four nucleate condition (Fig. 40) and then to an eight nucleate stage. Degeneration of four nucleate or eight nucleate embryo sac is very frequent so that the final organization of the nuclei to form a mature embryo sac is rare. In case embryo sacs reach maturity the nuclei of the embryo sacs organize to form an egg apparatus at the micropylar end, three antipodal cells at the chalazal end and two polar nuclei in the centre (Fig. 41). In one case, the antipodal cells showing abnormal elongation were seen (Fig. 42). The nucleus of one of these cells is abnormally enlarged.

mother cells. × 500. Fig. 38. A linear tetrad of megaspores. × 500. Fig. 39. L. S. ovule showing binucleate embryo sac. × 133. Fig. 40. Four nucleate embryo sac. × 320. Fig. 41. Mature embryo sac. × 333. Figs. 42-44. Abnormal embryo sacs. Note the enlarged *at* in Fig. 42, × 333: and the positions of the nuclei in Figs. 43 and 44. × 320.

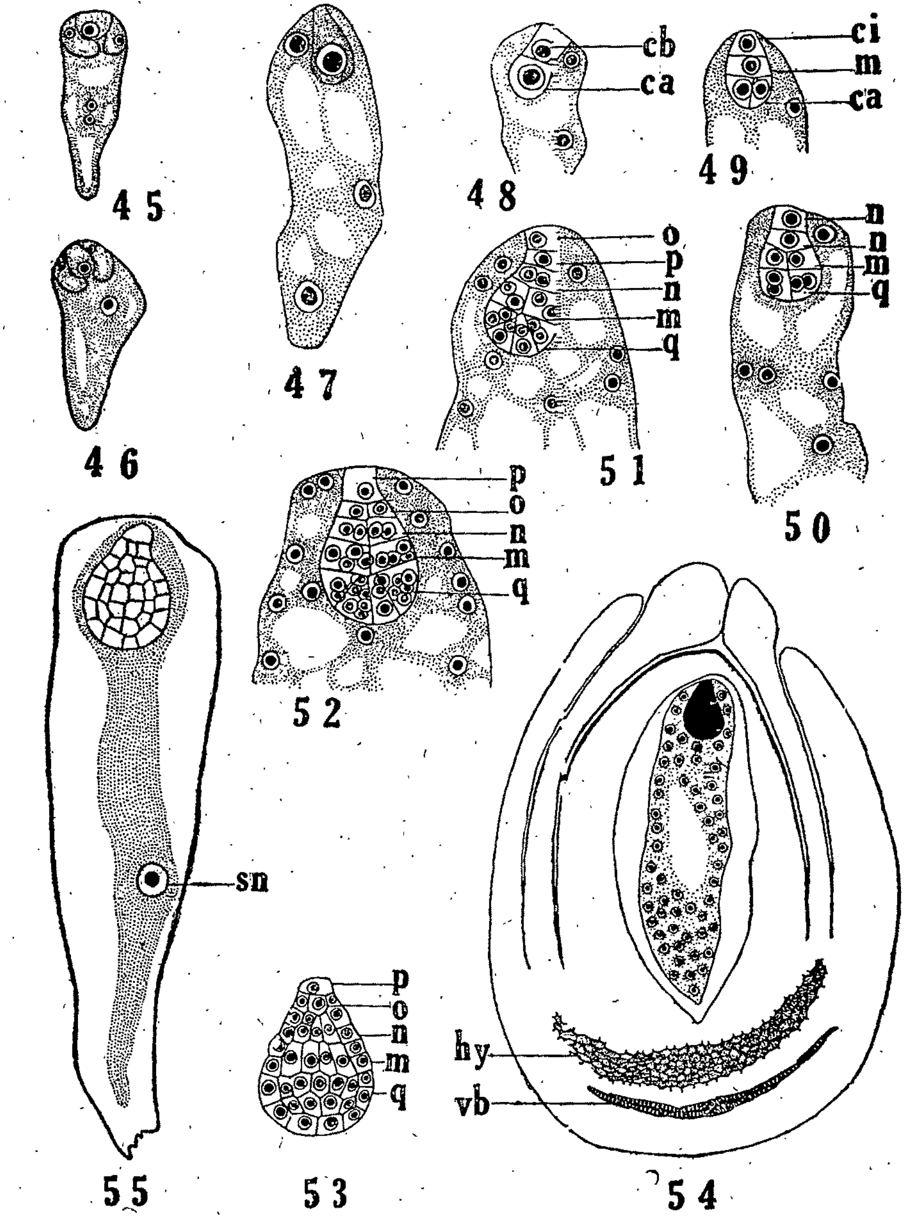
In certain cases, the embryo sacs show disturbed polarity and lack of organization. Thus, fig. 43 shows all the four nuclei situated in the centre and fig. 44 shows all the eight nuclei forming a central row. Such embryo sacs with disturbed polarity are functionless (18). In the cultivated seedless *M. alba* the organized embryo sacs degenerate in the absence of pollination because of lack of male plants. The abnormality in the organized embryo sac with regard to the antipodal cells is perhaps the sign of degeneration. The degeneration of the embryo sac and the ovule, thus, explains the lack of seed formation in the cultivated variety of *M. alba.*

An organized embryo sac of *M. indica* contains an egg apparatus and two polar nuclei (Fig. 45); the antipodal cells which are ephemeral like *Urtica urens* (19) disappear early. The synergids are sufficiently big and completely cover the egg. The secondary nucleus is formed by the fusion of the two polar nuclei (Fig. 46).

In case of *M. alba,* either at the binucleate or at the four nucleate stage of the embryo sac, a group of cells at the base of the nucellus become differenciated from the rest by having colourless shining walls ; which gradually become more suberized and lignified. By the time mature embryo sac stage is reached, a well marked hypostase becomes differenciated out of them. In *M. indica* a similar well differenciated hypostase is seen at the mature embryo sac stage and in the post fertilized condition of the ovule (Fig. 54).

EMBRYO AND ENDOSPERM

In M. indica embryo develops after Astrad type with a variation like that of *Urtica* (11). The zygote (Fig. 47) by a transverse division gives rise to a terminal cell and a basal cell (Fig. 48 *ca, cb*). Soon the basal cell (cb) divides transversely giving rise to two cells (Fig. 49, m, ci) while the terminal cell (ca) undergoes a longitudinal division. In the following stage, each of the four cells divide again (Fig. 50). The division of the cell (m) and those of the daughter cells from (ca) are longitudinal while (ci) divides transversely to form the daughter cells (Fig. 50 n and n′). The quadrant formed from (ca) is designated as (q). A transverse division of (n′) now gives rise to (o) and (p); while the division of



Text Figs. 45-55. Mature embryo sac and the development of embryo in *M. indica*. *hy.*, hypostase; *sn.*, secondary nucleus; and *vb.*, vascular bundle. Figs. 45, 46. Mature embryo sacs. Embryo sac with zygote and endosperm nuclei. × 500. Figs. 48-51. × 500. Figs. 48-51. Bicelled, four celled, eight celled and sixteen celled proembryos respectively. × 500. Figs. 52, 53. Advanced stages of the proembryo. × 500. Fig. 54. L. S. ovule showing *hy* and *vb* in the chalazal portion. × 100. Fig. 55. Embryo sac with a many celled proembryo and the undivided *sn*. × 500.

(n) takes place vertically; the two juxtaposed cells at (m) again divide vertically to produce four cells (Fig. 51). The quadrant at (q) divides by diagonal walls to form the octant (Fig. 51). In the next series of divisions (Fig. 52), there become 16 cells at (q), 8 at (m), 4 at (n), 2 at (o) while (p) may or may not divide transversely. Now in both tiers (q) and (m) tangential walls are laid down cutting off an outer layer of dermatogen cells from the inner cells which undergo further divisions to give rise to periblem and pleurome (Fig. 53). Finally the suspensor comes from (p), the root cap as well as the dermatogen of the root arise from (o), while (n) gives rise to the remaining part of the radicle, (m) to hypocotyl and (q) to the cotyledons and the plumule. The mature embryo is curved with a prominent radicle and fleshy cotyledons.

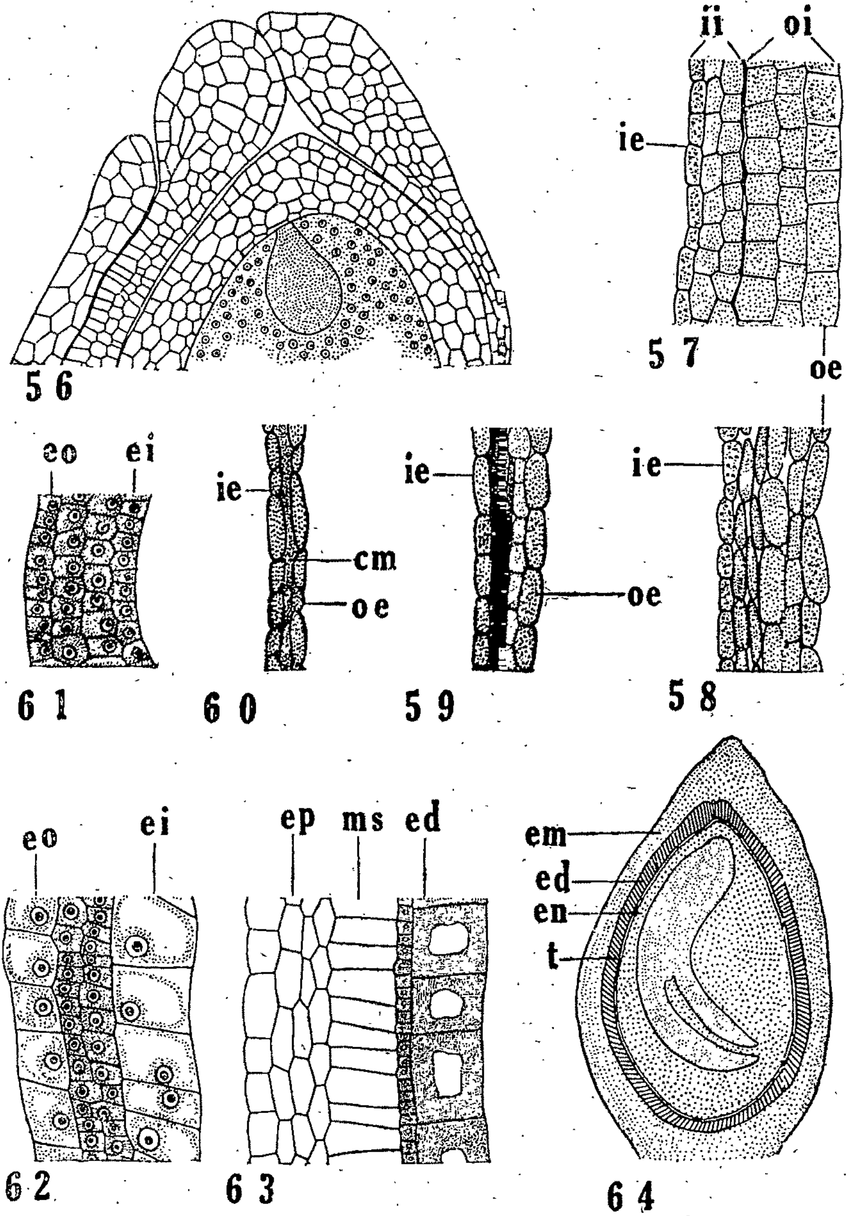
The primary endosperm nucleus by the free nuclear divisions forms a peripheral mass of nuclei lining the embryo sac (Fig. 54). The divisions are comparatively quicker towards the chalazal end. Cell formation begins quite late. As the endosperm grows the surrounding nucellar tissue is gradually destroyed leaving no nucellar remains in the mature seed.

A case of undivided secondary nucleus in an embryo sac with a many celled proembryo has been observed in *M. indica* (Fig. 55). Modilwesky (19) reported this in *Urtica cannabina* and *U. dioica*. Recently Dahlgren (7, 8) has figured embryo sacs of *Mitella pentandra* and *Zostera marina*, in which a several celled embryo is associated with an undivided secondary nucleus; Johansen (11, 12) has reported similar occurrences in *Taraxia ovata* and *Zauschneria latifolia*. The occurrence of undivided secondary nucleus is attributed to the single fertilization where the egg is only fertilized, the secondary nucleus remaining unfertilized and hence does not show division.

SEED-COAT

As there is no seed formation in the cultivated variety of *M. alba* the account of the further development of the ovule, therefore, deals only with that of *M. indica*.

Both the integuments are three layered excepting at the micropylar end which is broader (Fig. 56). In the post fertiliza-



Text Figs. 56-64. Seed-coat and pericarp. *cm.*, crushed intermediary cells between the outer epidermis of the outer integument and the inner epidermis of the inner integument; *ed.*, endocarp; *ei.*, inner epidermis; *em.*, epicarp and mesocarp; *en.*, endosperm; *eo.*, outer epidermis; *ep.*, epicarp; *ie.*, inner epidermis of the inner integument; *ii.*, inner integument; *ms.*, mesocarp; *oe.*, outer epidermis of the outer integument; *oi.*, outer integument and *t.*, seed coat, Fig. 56. L. S. young seed at the micropylar side. × 333 Fig. 57. L. S. portion of integuments from the middle.

tion stages the cells of both the integuments become tangentially elongated and all the layers between the outer epidermis of the outer integument and the inner epidermis of the inner integument are gradually crushed (Figs. 57-60), so that the seed coat is formed ultimately of the outer epidermis of the outer integument, the inner epidermis of the inner integument and a layer of crushed intermediary cells between the two above mentioned layers (Fig. 60). The cells of the outer and the inner layer of the seeed coat have thick walls and granular content. Seeds of *Broussonetia* (20), also possess the testa derived from both the integuments.

PERICARP

All the different layers of the fruit wall are derived from the four primary layers of the ovary wall (Fig. 61). The cells of the outer and the inner epidermis are small and slightly columnar while those of the ground tissue, which is formed of only two layers of cells, are large and polygonal in the beginning. As the development proceeds the cells of both epidermal layers increase in size and become highly vacuolated (Fig. 62), while the cells of the ground tissue are full of dense cytoplasm. Further increase in the thickness of the ovary wall is brought about by the tangential and the radial divisions in the first layer below the outer epidermis. The inner most layer of cells resulting from these divisons become columnar and radially elongated (Fig. 63). They form the mesocarp, while the rest of the tissue abutting upon the outer epidermis gives rise to the epicarp (Fig. 63). The cells of both these portions of the ovary wall contain sweet juice and form the sweet portion of the fruit. Sometimes, due to the large amount of sap stored in the epicarp cells as well, the cell size increases considerably and thus the distinction between the epicarp and the mesocarp cells becomes imperceptible. The inner epidermis and the remaining second primary layer of the ground tissue become thick walled and form the endocarp (Figs. 63, 64).

× 633 Fig. 58. L. S. showing the degeneration of the outer two layers of the inner integument. × 633. Fig. 59. Same slightly of advanced stage, degeneration extended to the inner layer of the outer integument. × 633. Fig. 60. Shows condition of the nearly mature seed coat. × 633. Figs. 61-63. Changes involved in the ovary wall leading to the formation of the pericarp. × 333. Fig. 64. L. S. mature fruit. × 35.

SUMMARY

Morus has both monoecious as well as dioecious species. The local cultivated variety of *M. alba* is found to bear female flowers only. The ovary wall near the stigmatic end, in rare cases, is found to possess pollen bearing sacs. Occasionally some flowers are found to have a bilocular condition of the pistil.

The pedicel of the female flower receives about 8 bundles which give up four traces, one to each of the perianth lobes. The perianth traces divide into three each before entering the lobes. The remaining tissue organizes to form an anterior dorsal carpellary and a common trace. This common trace divides immediately to form the ventral carpellary and the posterior dorsal carpellary trace.

The carpellary supply of the female flower with the bilocular ovary consists of an anterior, a posterior dorsal and a median ventral carpellary supply.

The comparative study of the floral anatomy of flowers having unilocular ovary with those having bilocular ovary shows the derivation of the former by the obliteration of the loculus of the posterior carpel.

In the pedicel of the male flower the vascular ring is similar to the female flower. A single vascular trace enters each of the perianth and stamen, which travel undivided throughout their length.

The anther wall consists of five layers, where the epidermal cells are heavily cutinized. The tapetum is of the glandular type.

Microspores are formed by the simultaneous divisions and are arranged in either tetrahedral or isobilateral manner. The pollen grains are shed at bicelled stage.

The ovule is bitegmic, crassinucellate and anatropous. The micropyle is formed by the inner integument and is very narrow.

The tip of the nucellus shows a group of hypodermal archesporial cells. Each divides transversely to give rise to a primary parietal cell and a sporogenous cell. All the sporogenous cells degenerate, except one which directly functions as the megaspore mother cell, and gives rise to a linear tetrad of megaspores. The chalazal megaspore develops to form the embryo sac after the Polygonum-type.

The embryo development is of Astrad type with a variation like that of *Urtica* (11). The endosperm development is free nuclear and the endosperm persistent in the seed.

The seed-coat is formed of the remnant of the two integuments consisting of three layers; outer of thick walled cells, central layer of crushed cells and the inner, again of thick walled cells resembling the outer layer.

The pericarp is differentiated into an epicarp of thin walled cells, mesocarp of radially elongated thin walled cells and an endocarp of thick walled lignified cells.

In *M. alba* very few embryo sacs reach maturity. Ultimately, however, all degenerate due to the absence of pollination, thus resulting in the lack of seed formation in the cultivated variety of *M. alba*. The fruits develop parthenocarpically.

I am deeply indebted to Prof. Bahadur Singh for his kind guidance throughout the course of the present investigation. Thanks are also due to Prof. P. Maheshwari for suggesting the problem and lending a few of his personal reprints. The author is also thankful to Dr. R. K. Singh, Principal, B. R. College, Agra, for facilities and encouragement.

LITERATURE CITED

1. Bechtel, A. R. 1921. The floral anatomy of the Urticales. *Amer. J. Bot.*, **8** : 386-410.
2. Bessey, C. E. 1915. The phylogenetic taxonomy of flowering plants. *Ann. Mo. Bot. Gard.* **2** : 109-164.
3. Buonocore, G. 1940. Contributo alla conoscenza del fiore di *Morus alba*. L. I. Morfogenesi fiorale (The flower of *M. alba*. L. I. Floral development). *Boll. R. Staz. Sperim. Gelsicolt. e. Bachicolt. Ascoli. Piceno.*, **19** (14/5) : 95-101., *Biol. Abs.*, 1950., **24** : Abs. No. 10300.
4. Capoor, S. W. 1937. The life history of *Holoptelia integrifolia*. *Beihefte bot. Centlbl.*, **57A** : 233-249.
5. Chamberlain, C. J. 1897. Contribution to the life history of *Salix*. *Bot. Gaz.*, **23** : 147-178.
6. Chapman, M. 1931. Carpel anatomy of the Berberidaceae. *Amer. J. Bot.*, **23** : 340-348.
7. Dahlgren, K. V. O. 1930. Zur Embryologie der Saxifragoideen. *Svensk Bot. Tidskr.*, **24** : 429-448.
8. Dahlgren, K. V. O. 1939. Endosperm und Embryobildung bie *Zostera marina*. *Bot. Notiser.*, pp. 607-615.
9. Farooq, M. 1952. An exceptional gynaecium in *Citrus medica* var. limon. L. showing adherent pollen chambers and extra ovarian ovule. *Curr. Sci.*, **21** : 72-73.
10. Hagerup, O. 1938. On the origin of some Angiosperms through the Gnetales and the Coniferae. III. The gynaecium of *Salix cinerea*. *K. Danske Vidensk. Selsk. Biolog. Medd.*, **14** : 4-34.
11. Johansen, D. A. 1931a. Studies on the morphology of the Onagraceae. III. *Taraxia ovata* (Nutt) Small. *Ann. Bot.*, **45** : 111-124.
12. Johansen, D. A. 1931b. Studies on the morphology of the Onagraceae. V. *Zauschneria latifolia*, typical of a genus characterised by irregular embryology. *Ann. N. Y. Acad. Sci.*, **33** : 1-26.
13. Johri, B. M. and Tiagi, B. 1952. Floral morphology and seed formation in *Cuscuta reflexa*. Roxb. *Phytomorphology.*, **2-3** : 162-180.
14. Juliano, J. B. 1935a. Morphological contribution on the genus *Anona*. *Philippine Agr.*, **24** : 528-541.
15. Juliano, J. B. 1935b. Morphology of the sweet potato, *Ipomoea batatus* (Linn.) Poir. *Philippine Agr.*, **24** : 833-858.
16. Juliano, J. B. 1935c. Anatomy and morphology of the Bunga, *Aeginetia indica* L. *Philippine Jour. Sci.*, **56** : 405-451.
17. Juliano, J. B. and Alcala, P. E. 1933. Floral morphology of *Musa errans* (Blanco) Teodoro var. *Botoan* Teodoro. *Philippine Agr.*, **22** : 91-126.
18. Maheshwari, P. 1950. An Introduction to Embryology of Angiosperms. New-York.

19. Modilwesky, J. 1908. Zur Samenentwicklung einiger Urticifloren *Flora.*, **98** : 423-470.
20. Netolitzky, F. 1926. Anatomie der Angiospermen-Samen. Berlin.
21. Nohara, S. 1934. Gametogenesis and embryogeny of *Sesamum indiqum.* L. *J. Coll. Agric. Tokyo Imp. Univ.*, **113** : 155-164.
22. Pande, S. K. and Shukla, K. P. 1954. On some abnormalities in the flower of *Morus alba* Linn. Pros. Ind. Sci. Cong., **3** : 130-131.
23. Puri, V. 1952. Placentation in Angiosperm. *Bot. Rev.* **18** : 603-651.
24. Rao, V. S. 1940. The occurrence of pollen grains in the ovary wall of *Dianthus. Curr. Sci.*, **9** : 77.
25. Roxburgh, W. 1832. See, Hooker, J. D. Flora British India, 1885., **5** : 492.
26. Schnarf, K. 1931. Vergleichende Embryologie der Angiospermen. Berlin.
27. Subramanyam, K. 1948. An Embryological study of *Melastoma malbathrcum* L. *Ind. Bot. Soc.*, **27** : 11-29.
28. Subramanyam, K. 1951. Embryology of *Oxyspora paniculata. Phytomorphology*, **2-3** : 205-212.
29. Welsford, E. J. and Benson, M. 1909. The morphology of the ovule and female flower of *Juglans regia* and a few allied genera. *Ann. Bot.*, **23** : 623-633.

GAMETOGENESIS AND FERTILIZATION OF *STEPHEGYNE PARVIFLORA* Korth*

By S. S. RAMAM, *Department of Botany, B. R. College, Agra.*

INTRODUCTION

A glance at the literature shows that the family Rubiaceae abounds with peculiar embryological features. As such, Schleiden (6) wrote long ago that ovules are naked in Rubiaceae. Houk (3) described the ovule of *Coffea* as devoid of nucellus and naked; he termed the ovule as composed of a tissue of 'integument-nucellus'. Fagerlind (2) has given an illustrated series of reduction of nucellus in the Rubiaceae; he has pointed out megaspore haustoria in the sub-genus *Eugalium* and abnormal positions of embryo sac in *Galium aparine;* his exhaustive work deals with the life-histories of a larger number of temperate genera and some tropical genera like *Ixora* and *Pavetta*. *Stephegyne parviflora* Korth, a tropical uninvestigated genus has been taken up for embryological studies. It is a deciduous tree flowering during the months of May to August at Agra.

MATERIALS AND METHODS

The material of *Stephegyne parviflora* Korth. was fixed by the author in July 1953, in formalin-acetic-alcohol at Agra. Tertiary-butyl alcohol was used for dehydration and the material was embedded in the usual way. Sections were cut 6 to 11 μ thick. Heidenhain's iron-alum-haematoxylin and safranin and fast-green proved satisfactory for study of embryotogical stages. Acetocarmin smears of anthers and stigmas were also studied.

EXTERNAL MORPHOLOGY OF FLOWER

The inflorescence is a terminal, pedunculate, globose cluster subtended by two leafy bracts. Flowers are bisexual. Bracts and bracteoles are paleaceous, covering the young florets, with their expanded, hood-like tips. Sepals are wanting. Corolla is funnel-shaped of five petals. The five epipetalous stamens, with their connectives prolonged beyond the level of theca, arise on the throat of corolla. The ovary is inferior, bicarpellary and bilocular, with a drooping placenta in each locule. The filiform style exserts out of corolla, with a terminal, columnar, solid stigma.

---

*This paper forms a part of the thesis submitted to the University of Agra in part fulfilment for the degree of M. Sc. in Botany (1954).

MICROSPOROGENESIS

A transverse section of young anther is somewhat rectangular in shape, in the four corners of which differentiate hypodermal bands of 4 to 5 archesporial cells (fig. 1). Periclinal divisions of archesporial cells follow and form a primary parietal and primary sporogenous layer (fig. 2). The primary parietal layer undergoes further periclinal divisions to form the wall of the anther which consists of an outermost layer, the epidermis, the endothecium, a single middle layer and a single layered tapetum doming the sporogenous tissue (fig. 3). Tangentially elongated epidermal cells of mature anther closely envelope endothecium which has now developed characteristic fibrous thickenings (fig. 4). The single middle layer disappears during meiotic divisions of microspore mother cells. The tapetum is secretory in nature and its cells are uninucleate throughout its life as in *Hamelia patens* Jaçq. and *Rubia cordifolia* (7). Plasmodium is never formed.

The primary sporogenous cells divide a number of times to form compact microspore mother cells, each of which is polygonal in shape with a prominent nucleus in dense cytoplasm. During meiotic divisions, the microspore mother cells remain compact. Figs. 5-8 show the course of first division of meiosis. Finally fig. 9 indicates bi-nucleate stage of microspore mother cell with no trace of intervening wall. Tetrads with microspores, mostly arranged tetrahedrally, sometimes isobilaterally, are commonly met with in this plant (figs. 10 & 11).

MALE GAMETOPHYTE

The microspores, released from the tetrads increase in volume to assume the characteristic shape of uninucleate pollen

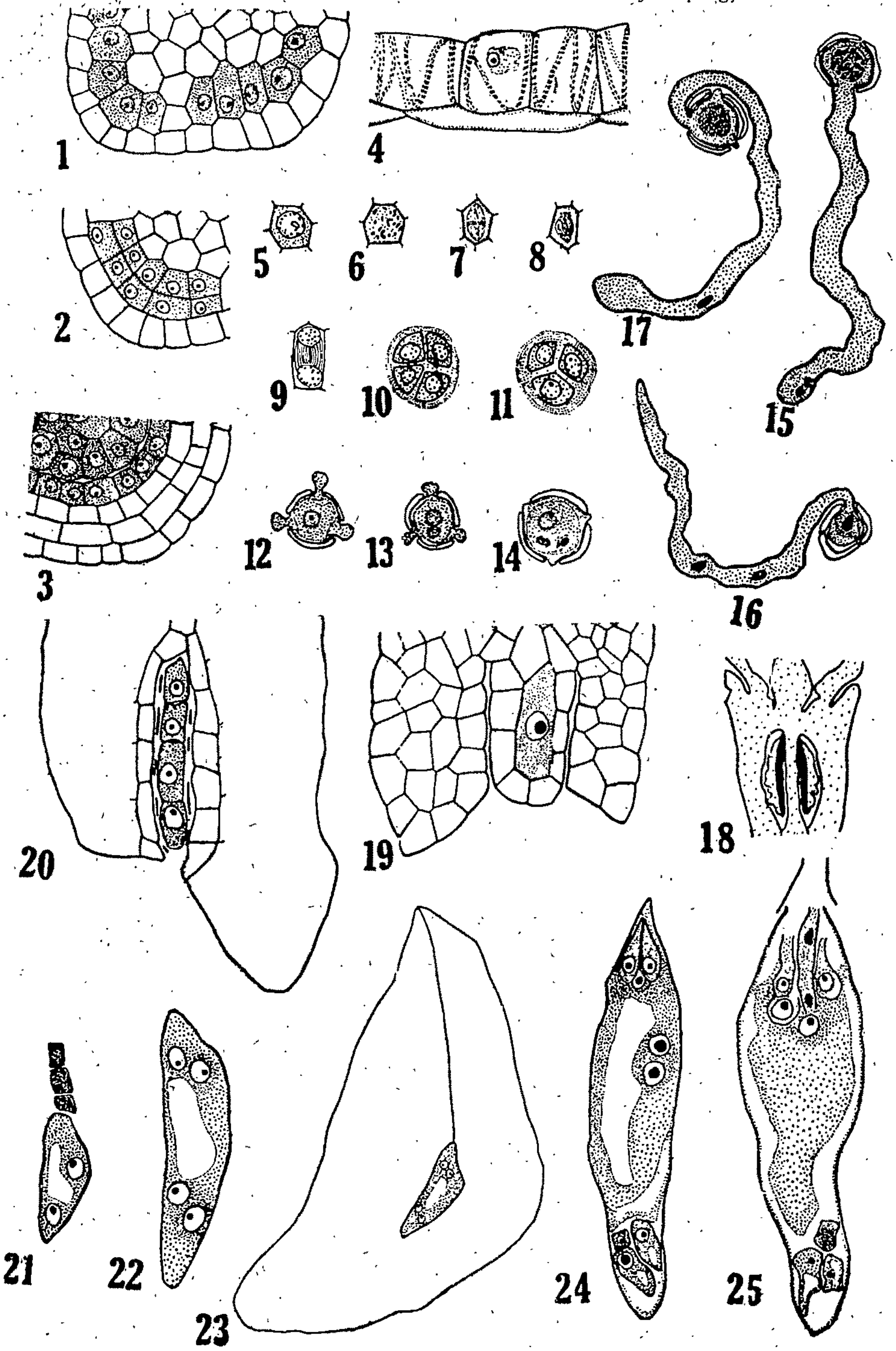


Fig. 1. T. S. anther, hypodermal archesporium. × 533. Fig. 2. Same, primary parietal and primary sporogneous layers. × 533. Fig. 3. T. S. anther showing wall layers & microspore mother cells. × 533, Fig. 4 L. S. of anther wall, showing persistent epidermal cells and fibrous

grains with three germ pores (fig. 12). The intine markedly protrudes out of the germ pores and centrally placed nucleus undergoes division to form upper vegetative nucleus and lower generative nucleus (fig. 13). Fig. 14 shows 3-celled pollen grain at which stage, it is ready to be shed.

Some germinating pollen grains collected from stigma show some interesting features. Thus, in some instances the pollen-tube, after emerging out of pollen grain, coils up, presumably in an attempt for an effective entrance into stigma. In one case (fig. 15) the contents of the body of the pollen grain, as they have taken a deep acetocarmin stain, are not clear but two male gametes are found in the tip of pollen-tube. In another case (fig. 16), the vegetative nucleus is found to be in the body of pollen grain, with two male gametes advancing towards the tip of the pollen-tube. In the third case, it is interesting to find that a single darkly stained nucleus has entered the tube, while there is no trace of vegetative nucleus in the body of pollen grain (fig. 17). From the above, it is evident that the vegetative nucleus, probably has disorganised and does not enter the pollen-tube.

PLACENTATION

Fig. 18, shows that there are two placental strands, each of which hangs down from the top of each loculus of bilocular ovary. Placental strands, at their very inception, are attached to the central septum, but lower down they are free laterally from the wall of each loculus as well as the central septum. The pendulous placental strand bears laterally numerous ovules, and is peculiar to this genus. It is in striking contrast to the current

endothecium. x 533. Figs. 5-9. 1st meiotic division of microspore mother cell. (Figs. 5-8. x 533, fig. 9. x 570). Figs. 10 & 11 Microspore tetrads. x 533. Fig. 12. Uninucleate pollen grain x 533. Fig. 13. Bicelled pollen grain. x 533. Fig. 14, Three-celled pollen grain. x 533. Figs. 15-17. Germinating pollen grains. x 533. Fig. 18. L. S. inferior ovary, note the pendulous placenta. x 20. Fig. 19. L. S. Ovule; note the single integument, female archesporium and the nucellar epidermis. x 533. Fig. 20. L. S. Ovule, linear tetrad of megaspores; note the remains of nucellus. x 533. Fig. 21 Binucleate embryo sac. x 533. Fig. 22. Four-nucleate embryo sac. x 533. Fig. 23. L. S. Ovule, showing massive integument, and narrow micropyle. x 430—Fig. 24. Organised embryo sac. x 533. Fig. 25. Embryo sac markedly elongated; note the pollen tube entering through the micropyle, and one degenerating antipodal cell plus two others vacuolated. x 533.

view that gynoecium in Rubiaceae possesses an axile or seemingly basal placenta.

OVULE

A large number of ovular primordia arise on the placental strands described above. A single integument, which arises laterally around the nucellus, comes in level with its tip, by the time a single archesporial cell is differentiated in the nucellus (fig. 19). Further growth of the integument, which is more pronounced than that of nucellus results in the formation of micropyle which faces downwards in relation to pedicel (fig. 23). The nucellar epidermis consists of 5 to 7 tangentially elongated cells, forming a dome around the archesporium, as in *Phyllis* (1) *Guettarda speciosa* (5).

MEGASPOROGENESIS AND FEMALE GAMETOPHYTE

The single archesporial cell functions directly as megaspore mother cell and experiences usual meiotic division resulting in a linear row of four megaspore cells (fig. 20). By this time nucellar epidermis has undergone advanced degeneration.

The chalazal megaspore cell functions while others degenerate (fig. 21). The nuclei of the 2-nucleate embryo sac move apart to their respective poles with a prominent vacuole in the centre. Then follow 4-nucleate and 8-nucleate embryo sacs (figs. 22 & 24), the development of which follows the *Polygonum*-type (4). The organised embryo sac (fig. 24) shows synergids with tapering apical ends and hemispherical bases. The egg is situated below the synergids in dense cytoplasm. One of the three antipodals, at chalazal end, is more or less quadrangular in shape with a small nucleus while the other two possess a prominent nucleus each. Antipodals are present at the time of entrance of pollen-tube into the embryo sac.

FERTILIZATION

As stated earlier, stigmas of many open flowers are covered with pollen-tubes which ultimately enter the embryo sac of a number of ovules. Fig. 25 shows part of the pollen-tube wedged between two synergids which are thus not destroyed by pollen-tube entry. The pollen-tube has two male gametes in dense cytoplasm. No trace of synergids and antipodal cells is seen in embryo sacs with zygotes.

SUMMARY

Anther is tetralocular; connective prolonged beyond the theca into a sac. Wall of the anther shows an external epidermis, fibrous endothecium and a single middle layer. Tapetum is single-layered and secretory in nature Its cells are uninucleate. The reduction divisions are simultaneous. Tetrahedral and isobilateral tetrads are formed. The mature pollen grain is 3-celled with three germpores and is shed at this stage.

Ovule is anatropous, unitegmic and tenuinucellate. Archesporium is single celled and directly functions as megaspore mother cell. Linear-tetrad of megaspores are formed and chalazal magaspore is functional; the development of embryo sac is of *Polygonum* type. Pollen-tube enters through the micropyle. Synergids and antipodal cells disappear after fertilization.

ACKNOWLEDGMENTS

My sincere thanks are due to Prof. Bahadur Singh for suggesting me the problem and for his constant guidance and encouragement throughout the progress of this work. I am thankful to Shree M. B. Raizada, Systematist, Forest Research Institute, Dehra Dun, for kindly identifying the plant.

LITERATURE CITED

1. FAGERLIND, F. 1936. Embryologische Beobachtungen über die Gattung *Phyllis*. *Bot. Notizer,* 557-584.
2. FAGERLIND, F. 1937. Embryologische, zytologische und bestaubungsexperimentelle Studien in der Familie Rubiaceae nebst Bemerkungen über einige Polploiditätsoprobleme. *Acta Horti Bergiani,* **11** : 195-470.
3. HOUK, W. G. 1938. Endosperm and perisperm of *Coffea* with notes on the morphology of the ovule and seed development. *Amer. J. Bot.,* **25** : 56-61.
4. MAHESHWARI, P. 1950. An Introduction to the Embryology of Angiosperms. New York.
5. RAGHAVAN, T. S. and SREENIVASAN, K. V. 1941. Studies in Rubiaceae. *Spermacoce hispida* Linn, *Guettarda speciosa* Linn. and some cytomorphological considerations. *Proc. Indian Acad. Sci.,* **4** : 412-426.
6. SCHLEIDEN, M. J. 1837. Einige Blicke auf die Entwicklungsgeschichte der vegetablischen Organismus bei den Phanerogamen. *Wiegmanns Achiv,* **3** : 289-320.
7. VENKATESWARLU, J. and RAJESWARA RAO, G. 1954. Contribution to the embryology of *Rubia cordifolia* and *Hamelia patens* Jacq. *Indian Sci. Cong. Assoc. Proc. of* 41 *session,* Hyderabad (Deccan). Section Botany, 144.

FLORAL ANATOMY OF *HELIOTROPIUM INDICUM* L.

By RAMJI SHARMA, *Department of Botany, B. R. College, Agra.*

The family Boraginaceae, though well represented in India, has received little attention so far as its floral anatomy is concerned. Svensson (19) and Souèges (18) are the only recent authorities on its embryology. Lawrence (12) has critically examined the floral anatomy of the family and has supported the classification of the family by Gurke (6) into 5 subfamilies on the basis of floral anatomy. Most of the taxonomists (1, 3, 16) include it in Tubiflorae while Hutchinson (8, 9) and Gundersen (5) raised it to a new order Boraginales and Hallier (7) placed it under Campanulinae. Since the role of floral anatomy in taxonomic problems is duly recognized (14), it is hoped that a closer study of the floral anatomy of this family may yield useful grounds for its taxonomic position. Moreover, the family has many points of interest e.g. the corolline corona, the pseudomonomerous condition of the gynaecium (11), the floral disc, the gynobase, the nutlet formation, the highly specialized stigma in the subfamily Heliotropioideae and the solid stylar canal. It is on account of these diverging opinions as well as the absence of work on tropical species, that the present piece of work has been undertaken.

MATERIAL AND METHODS

The material for the present study was very kindly passed over to me fixed in formalin-acetic-alcohol at Bharatpur by my colleague Mr. S. P. Singh. The buds as well as mature flowers were dehydrated through normal-butyl alcohol series, embedded in paraffin and cut transversely and longitudinally at 8-10 μ thick. These were stained with safranin-fast-green or haematoxylin-erythrosin combinations. The treatment of the sections with 1·% chromic acid for two hours before staining, improved the staining considerably.

A new technique of whole mounts was also tried. This consisted of clearing the flowers by boiling them in 10% KOH for five minutes and staining it with basic fuchsin after thorough washing with water. Destaining was done with lactophenol which made the material transparent and only xylem elements retained a bright red stain. Figs. 21 and 22 have been drawn from material prepared after this technique, while fig. 6 has been constructed on the basis of a combined study of the whole mounts and the serial cross-sections.

The pollen tubes were studied by boiling fresh flowers of *Heliotropium strigosum* L. in 5% KOH and staining it with cotton blue after thorough washing.

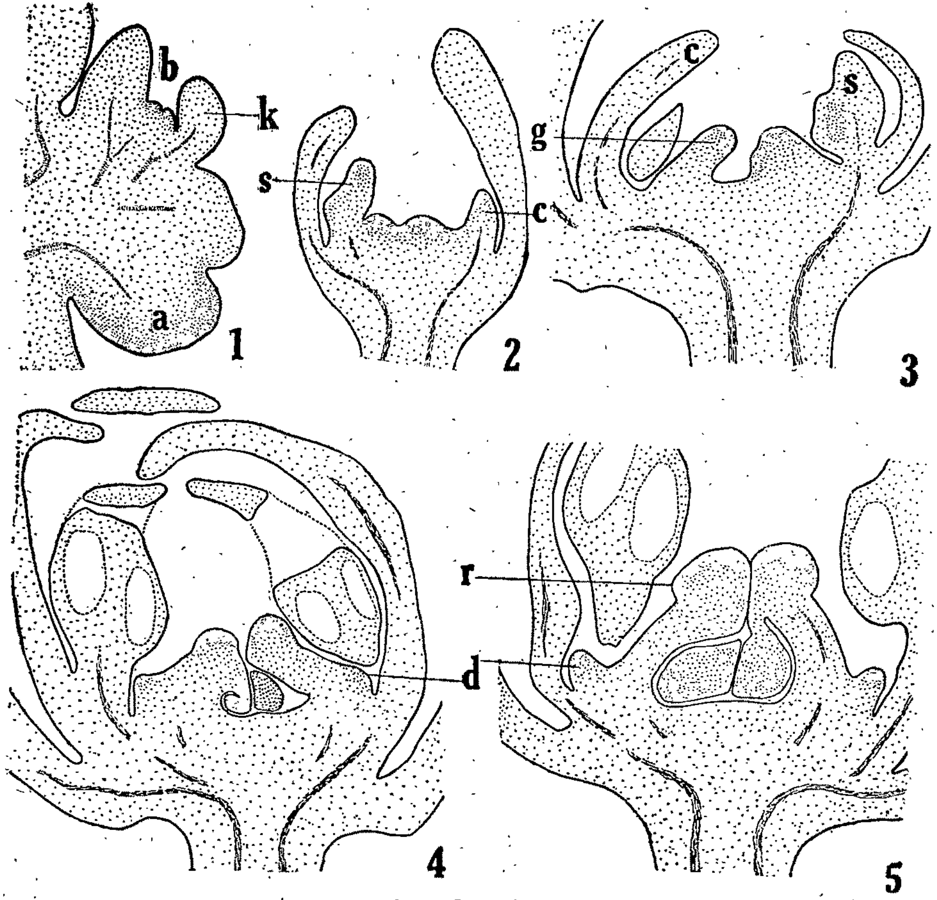
THE FLOWER

The ebracteate, subsessile flowers are arranged on a forked, coiled circinus in two rows. Five persistent sepals, slightly fused at the base, envelop the whole flower except at the top, where five reflexed lobes of the campanulate corolla protrude out. Five oblong, four-chambered, epipetalous anthers are inserted on short filaments in the corolline tube. A little below the level of attachment of the filaments and alternating with them, there are present five short, inconspicuous outgrowths in the corolla tube. This forms the corolline corona, which has hitherto been unreported. It differs from the corolline corona in the subfamily Cynoglosseae in its inconspicuous growth and deeply situated position inside the corolla tube. The slightly four-lobed ovary rests on a prominent disc. The style is terminal and ends in a conical stigmatic head that bears a papillate stigmatose ring at the base of the stigmatic head.

Stiff, pointed, unicellular hairs with a bulbous base are densely distributed over the sepals and sparsely over the stigma and the style.

ONTOGENY OF THE FLOWER

The floral apex is a dome shaped structure (Fig. 1 a) on which the primordia arise in acropetal succession. The calyx primordia originate along the base of the dome as five protuberances. The procambial strand of the dome becomes well marked and the branches in the calyx lobes are established at a very early stage (Fig. 1 b). Just above the calyx primordia and alternating with them, there arise five protuberances as the common primordia for petals and stamens (Fig. 2). They fuse laterally to form a complete ring. On the inner side of this tube, five initials for stamens become differentiated opposite the calyx lobes. The stamen primordia appear so early after the initiation of the common primordia that it is hardly possible to get a section showing petal primordia alone. However, the course of procambial differentiation is found to be acropetal; first the branches being established with petals and then with the stamens (Figs. 2, 3). A similar case has been described in *Vinca rosea*



Text figs. 1—5

Fig. 1. L. s. tip of inflorescence, showing floral primordia *a* and *b* at different stages of growth. Fg. 2. l. s. flower, slightly advanced to show corolla, *c*, stamen, *s*, primordia. Fig. 3. slightly older than Fig. 2. showing carpel primordia, *g*; Fig. 4. slightly older than Fig. 3. showing origin of disc, *d*; and the initiation of ovules. Fig. 5. floral bud showing the closure of the carpels and its rim, *r*. (All figs. × 130).

by Boke (2). The stamen primordium is thicker than its length and shows a hump on its abaxial side which represents the common base of the two adjacent petals (Fig. 2).

The carpel initials arise later as two semi-circular outgrowths near the apex of the dome (Fig. 3). At the base of the carpel, a proliferation arises on the abaxial side. This represents the characteristic disc of the ovary (Fig. 4). The carpels fuse along their adjacent margins to form a unilocular structure and show characteristic stigmatic reflexed rims (Figs. 4, 5 and 6). A single massive placenta arises on each side of the fused margins to bear a single pendulous ovule on each one of them (Fig. 5).

The placentation in the family has all along been held to be axile, but the ontogenic studies in the present material reveal that its nature is parietal. The margins of the carpels, bearing the massive placentae, never fuse in the centre; though they approach each other very closely (Fig. 6, level as well as Fig. 14). The unilocular condition of the ovary is very clear at this level of the attachment of the ovules with the placentae, while lower down, the inward growth of the ovary wall along the mid-rib of the carpels (Fig. 6, level and fig. 13) fuse with the massive placentae, which themselves fuse together and this produces a tetralocular condition (Fig. 6, level & fig. 12). Saunders (17) also describes the condition of the ovary in Boraginaceae as unilocular, but having the appearance of being quadrilocular. A similar condition is evident from figs. 1 : a_3, c and f_2 of *Cortesia cunnifolia* by Junell (11). Thus the ovary is unilocular and the ovules are borne on the fused margins of two different carpels. These two points fully satisfy the criteria put forth for the parietal type of placentation (15). In such cases where there occurs an excessive growth of the placental column, an impression of axile character may be wrongly manifested. This was for some time the case with *Martynia*, formerly a genus of Pedaliaceae, which now by its parietal character of placentation, has been assigned to a separate family, Martyniaceae.

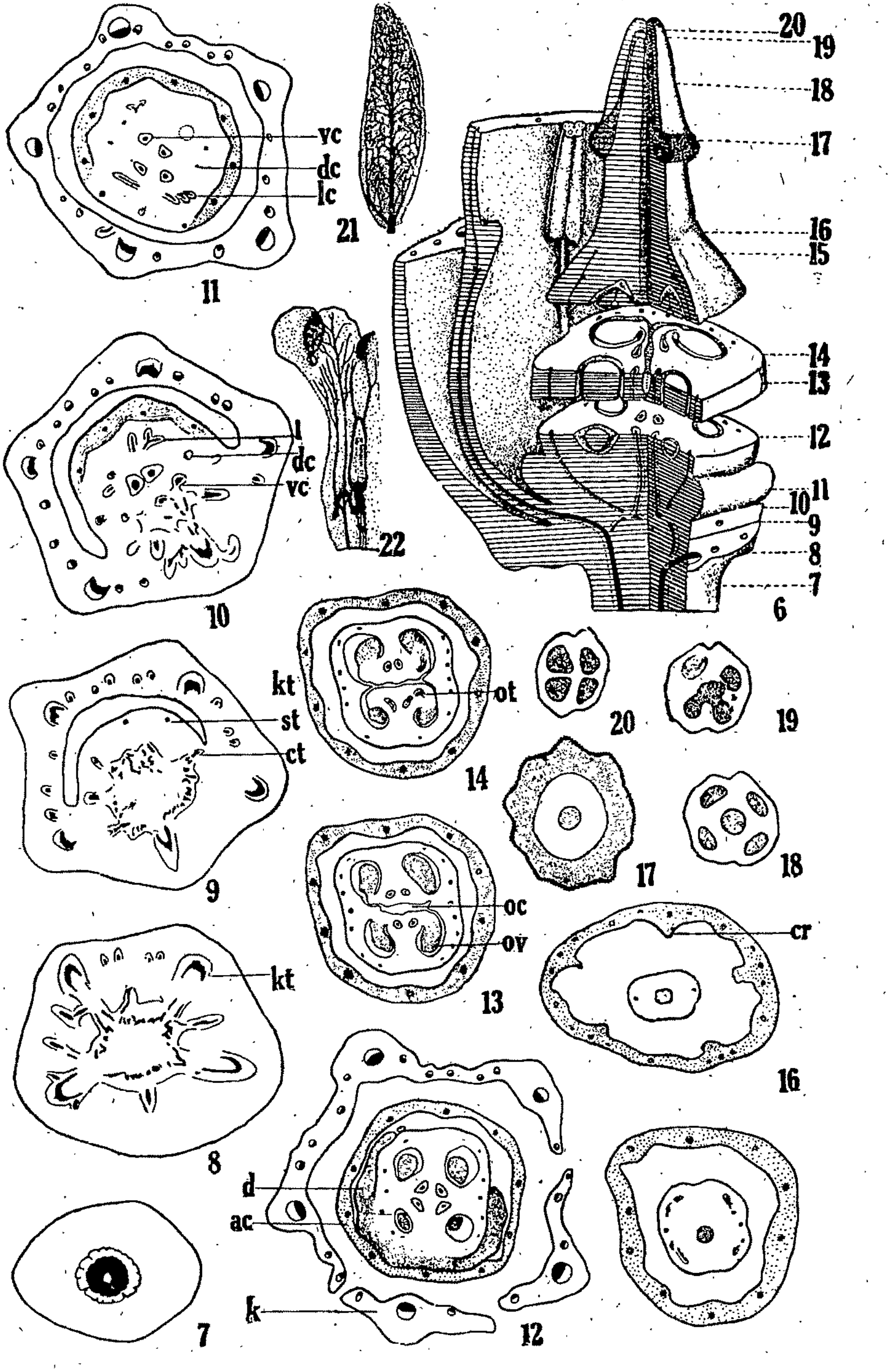
The reflexed rims of the carpels form a conical stigmatic head by the rapid growth of the apical side, and so the rim remains down below forming the stigmatose ring at the base.

ANATOMY OF THE FLOWER

Fig. 6 presents a perspective view of the whole flower cut in two longitudinal planes at right angles to each other, so as to remove a single quadrant. The ovary has also been shown cut at two transverse planes. The transection of the pedicel at the level 7 shows a continuous ring of twelve to eighteen vascular bundles with a narrow pith (Fig. 7). Higher up, at the level of the calyx insertion, five strong traces depart from the central stele to supply the calyx lobes (Fig. 8). These traces give out a lateral trace on either side and thus they enter the calyx. Profuse branching of these strands in the calyx lobes produces a net-work of closed veins (Fig. 21).

After the departure of the calyx traces, the vascular elements again organise into a ring with a wide pith in the centre. A little above the calyx traces, at the levels 9 and 10, ten traces are given out from the re-organised central stele (Figs. 9, 10). Out of these ten traces, five stronger ones (ct) which alternate with the calyx traces (kt) are destined to supply the corolla; and the other five supply the stamens. All these traces run unbranched to a considerable length in the andro-corolline tube. A little below the level of attachment of the filaments (level 16, Fig. 6), the corolla traces pass off two laterals which swing rapidly outward and upward to reach upto the bases of the free lobes of the corolla (Fig. 22). Fig. 16 shows the trans-section at this level where the corolla traces have divided into three, while the stamen traces are single and supply the stamens as such. At this level is also seen the inward growth of the corolla tube which forms the inconspicuous corona. The corona receives no vascular supply. It probably is, a mere localised folding of the inner surface of the corolline tube, which is evident during the ontogeny of the corolla. (Figs. 4, 5). Lindley's (13) contention, however, that these represent the abortive stamens, is not tenable, as has also been refuted by Gürke (6). Profuse branching of the median strand of the corolla occurs in the free lobes and the veins end blindly (Fig. 22).

The vascular tissue left after the departure of the traces for corolla and androecium, organises itself into a ring of ten vascular



Text Figs. 6-22.

Fig. 6. diagramatic model of the flower. The numbered levels correspond to the different figs. in t. s. × 38. Fig. 7. t. s. of the pedicel. × 50 . Fig. 8. t. s. showing the calyx traces (*kt*) and bundles. Out of these ten bundles, the two bundles situated in the anterio-posterior direction form the two weak dorsals of the two carpels (Fig. 10). Just at right angles to these, two lateral traces (*lc*) in each carpel arise, which move rapidly towards the periphery in the ovary wall along the dorsals and divide into three (Figs. 10, 11). Lawrence (12) writes in case of *Heliotropium peruvianum* that the laterals arise adjacent on either side of the dorsals, which is not confirmed in the present study. Of these lateral strands, those that lie adjacent to the dorsals are the strongest (Fig. 12). In longisections (Fig. 6), they are seen to curve and are the ovarian cavity laterally on the upper side. There they often meet with their branches (Fig. 15). The dorsals, however, continue their ascent up the style and reach upto the stigmatose ring, where they are lost in the stigmatoid tissue (Figs. 16, 17). It is often difficult to trace them in the stylar region as they retain their procambial stage and seldom show any spiral element. At the level 11 (Fig. 6) there remain now four strong amphicribral strands in the centre (Figs. 10, 11), which ascend up and directly supply the ovules (Fig. 14), reaching upto the chalaza. These represent the fused ventral and the ovular traces (12). A little above this level is seen the characteristic disc which surrounds the base of the ovary (Fig. 12). The disc receives no vascular supply and represents only a proliferated area at the base of the carpels. This proliferation is seen at an early stage even when the carpels have not completely closed.

The subfamily Heliotropioideae is characterised by the possession of a highly specialized stigmatic head. The style is solid and has a loosely packed conducting tissue* formed of

the laterals. × 33. Fig. 9. t. s. showing the separation of calyx and the corolla traces (*kt*, *ct*) and androecium traces (*st*). × 33. Figs. 10 & 11. t. s. showing the separation of the corolline tube, origin of the dorsal carpellary traces (*dc*), ventral carpellary traces (*vc*) and the lateral carpellary traces (*lc*), × 33. Fig. 12. t. s. showing the free calyx lobes (*k*), andro-corolline tube (*ac*), floral disc (*d*) and tetralocular ovary. × 33. Fig. 13. t. s. showing the continuous ovarian cavity (*oc*). The calyx has not been shown further. *ov.* ovule. × 33. Fig. 14. t. s. showing the parietal nature of the placentation and the ovular traces (*ot*). × 33. Fig. 15, t. s. showing the anastomosing of the lateral carpellary traces. × 33. Fig. 16. t. s. showing the corolline orona (*cr*) and the divided corolla strands. Note the dorsals and the transmitting tissue in the style × 33. Figs. 17-20. t. s. of the stigmatic head at different levels (cf. fig. 6). × 50. Fig. 21. whole mount of calyx. × 8. Fig. 22 whole mount of a part of the andro-corolline tube showing the corona, branching of the corolla strand and a stamen. × 8.

---

*Joshi (10), however, uses the term stylar canal for such solid styles.

cells that take up a dark stain. These cells make their appearance near the attachment of the ovules and line the ovarian cavity along the placental column. As the cavity narrows, the lining cells become grouped and form a vertical column in the centre of the style. A new name, the stigmatoid tissue, has been proposed by Esau (4) for such tissue; but the older name, the transmitting tissue, seems more appropriate as it defines its physiological entity also. Secondly, in *Heliotropium spp.* the stigma is not covered with such tissue and so the term, stigmatoid tissue, is erroneous. This central transmitting strand divides near the apical notch of the stigma (level 20, Fig. 6) into four branches (Fig. 20). These branches, after a short ascent in each of the two lobes of the stigma in pairs, suddenly take a downward curve and descend down to the base of the stigmatic head. Hence a transection in the middle of the stigmatic head (level 18, Fig. 6) shows one central and four peripheral patches of the transmitting tissue (Fig. 18). At the basal region of the stigmatic head, which apparently becomes decagonal, all the four branches extend laterally and coalesce together to form a ring that extends to the outer epidermal layer (Fig. 17). The epidermal cells of this region become elongated and this gives the base of the stigmatic head a papillate appearance. Pollen grains have been found to germinate along this stigmatic ring only and the pollen tubes follow the path of the branches of the transmitting strand.

The nature of the transmitting strand is a point of much controversy. Joshi (10) regards it as a modification of the ventral carpellary traces, while Lawrence (12) holds it to be an independent tissue, at least in Boraginaceae, as in some members of this family the ventral carpellary traces have been found to persist side by side the transmitting strand. Thomas (20), however, regards this tissue as a modified epidermis. It would be unsafe to arrive at any conclusion unless more genera of this family have been studied.

SUMMARY

The ontogeny and the anatomy of the flower of *Heliotropium indicum* L. is described in this paper.

The floral parts arise in acropetal succession.

There is an inconspicuous corolline corona deeply situated inside the corolla tube.

The calyx receives five strong traces which give off two laterals before entering into the calyx lobes.

The ten traces for corolla and androecium are given out simultaneously. The stamen traces remain unbranched throughout, while the corolla traces pass off two laterals near the level of the corolline corona and all of them divide profusely in the free lobes of the corolla.

Each carpel receives one dorsal, two ventrals and a pair of laterals which divide into three, surround the ovarian cavity laterally and often anastomose among themselves. The dorsals continue up the style to the base of the stigmatic head. The ventrals directly supply the ovules.

The placentation is found to be parietal.

The author is highly grateful to Prof. Bahadur Singh for his guidance throughout the progress of the work. Thanks are also due to Dr. V. Puri for his valuable suggestions and to Dr. R. K. Singh for the facilities and the encouragement.

LITERATURE CITED

1. BESSEY, C. E. 1915. The phylogenetic taxonomy of flowering plants. *Ann. Mo. Bot. Gard.*, **2** : 109-164.
2. BOKE, N. H. 1949. Development of the stamens and carpels in *Vinca rosea* L. *Amer. Bot.*, **36** : 535-547.
3. ENGLER, A. and K. PRANTL. 1897. Die Natürlichen Pflanzenfamilien. **4** : 71-131.
4. ESAU, K. 1953. Plant anatomy. John Wiley & Sons. Inc.
5. GUNDERSEN, A. 1950. Families of Dicotyledons. Waltham Mass., U.S.A.
6. GÜRKE, M. 1897. Borraginaceae.—Engler, A. und Prantl, k.; Die Natürlichen Pflanzenfamilien. **4** : 71-131.
7. HALLIER, H. 1912. L. origine et le systéme phylétique des angiospermes. *Arch. Néerl. Sci. Exact. Nat.*, (IIIB) **1** : 146-234.
8. HUTCHINSON, J. 1926. The families of flowering plants. I, Dicotyledons. London.
9. HUTCHINSON, J. 1948. British flowering plants. London.
10. JOSHI, A. C. 1934. Morphology of the stylar canal in Angiosperms. *Ann. Bot.*, **48** : 967-974.
11. JUNELL, S. 1938. Über den Fruchtknotenbau der Borraginazeen mit Pseudomonomeren Gynazeen. *Svensk. Botanisk Tidskrift.*, **32** : 261-27.
12. LAWRENCE, J. R. 1937. A correlation of the taxonomy and the floral anatomy of certain of the Boraginaceae. *Amer. J. Bot.*, **24** : 433-444.
13. LINDLEY, J. 1853. The vegetable kingdom.
14. PURI, V. 1951. The role of floral anatomy in the solution of morphological problems. *Bot. Rev.*, **17** : 471-553.
15. PURI, V. 1952. Placentation in Angiosperms. *Bot. Rev.*, **18** : 603-651.
16. RENDLE, A. B. 1938. The classification of flowering plants. Vol. II. Cambridge.
17. SAUNDERS, E. R. 1939. Floral morphology: a new out-look. Vol. II. Cambridge.
18. SOUÉGES, E. C. R. 1923. Development de l'embryon chez le *Myosotis hispidula*. *Bull. Soc. Bot. France.*, **70** : 385-401.
19. SVENSSON, H. G. 1925. Zur Embryologie der Hydrophyllaceen, Borraginaceen und Heliotropiaceen. *Uppsala Univ. Arsskr.*, II.
20. THOMAS, H. H. 1934. The nature and origin of stigma. A new contribution towards a new morphological interpretation of angiosperm flower. *New Phyt.*, **33** : 173-198.

EFFECT OF MIXED CROPPING ON THE INCIDENCE OF ROOT-ROT, WILT AND ASSOCIATED DISEASES OF *CYAMOPSIS PSORALIOIDES*

By R. S. Singh, Lecturer in Plant Pathology, Govt. Agricultural College, Kanpur.

INTRODUCTION

Mixed cropping is well known as one of the important measures to secure the crop against losses by various plant pathogens, especially those perpetuating and spreading through soil. Taubenhaus and Ezekiel (4) reported that by creating barriers between rows of cotton with intervening rows of *Sorghum* the mortality due to Texas root-rot, caused by *Phymatotrichum omnivorum* (Shear) Duggar, was considerably reduced. They explained the phenomenon to be due to interruptions in root contacts. Vasudeva and Ashraf (6) found that in a mixed crop of cotton and *Sorghum* the death of cotton plants from root-rot, caused by *Rhizoctonia solani* Kuhn. and *Rhizoctonia bataticola* (Taub.) Butl., was significantly less than those in cotton alone. They attributed this reduced mortality to the shading effect of the *Sorghum* in lowering soil-temperature. Vasudeva (5) further amplified these results. He reported that growth of *Phaseolus aconitifolius* Jacq. in between the cotton rows not only reduced the mortality in cotton from more than fifty percent in the pure stand to a negligible percentage in the mixed crop but also significantly increased the yield of seed cotton. Soil-and air-temperatures were lower in the mixed crop and humidity was higher than in the pure cotton. At the same time in a mixed crop of cotton and *Panicum colonum* Linn. soil-and air-temperatures were not lower than those in the pure cotton; nevertheless mortality due to root-rot was significantly lower in the mixed crop than in the pure stand of cotton. Thus Vasudeva concluded that not only temperature but "other factors" also play some role in a mixed crop to reduce the incidence of root-rot. According to Garrett (1) "one such 'other factor' that is likely to operate in reducing mortality due to disease in mixed crop (where the plant used for inter-cropping is immune to infection) is the interruption of root-contacts between susceptible plants by the roots of immune plants". Reduced disease-incidence due to lowering of the temperature in a mixed crop has also been reported by Hansford (2). However, in many instances the shading has been found to increase the disease-incidence instead of decreasing it (1).

Root-rot and wilt of *Cyamopsis psoralioides* DC., caused by *Rhizoctonia solani* Kuhn. and *Fusarium coeruleum* (Lib.) Sacc. (3), are the most serious diseases of this crop in Uttar Pradesh. *R. solani* also causes the seedling-rot and leaf-blight of older plants under favourable weather conditions. During studies on these diseases some experiments were carried out to assess the efficacy of mixed- and inter-cropping in minimizing the crop losses.

EXPERIMENTAL METHODS

The various crops used in these experiments were as follows:

1. *Cyamopsis psoralioides* alone
2. *Cyamopsis* and *Vigna catjang*
3. *Cyamopsis* and *Phaseolus aconitifolius*
4. *Cyamopsis* and *Sorghum vulgare*
5. *Cyamopsis* and *Glycine soja*
6. *Cyamopsis*, *Vigna* and *Ph. aconitifolius*
7. *Cyamopsis*, *Sorghum* and *Ph. aconitifolius*
8. *Cyamopsis*, *Sorghum* and *Ph. mungo*
9. *Cyamopsis*, *Ph. mungo* and *Ph. radiatus*
10. *Cyamopsis*, *Sorghum*, *Vigna* and *Ph. aconitifolius*

Seeds were sown broadcast in two series of experiments. Disease incidence was studied in both of them but the crop in one series was harvested for fodder, while the other was left to ascertain the grain yield. In the third series the mixed seeds were sown in 18-feet long rows each two feet apart. The fourth series consisted of rows of pure *Cyamopsis* inter-cropped with rows, (each two feet apart), of other crops and a distance of 2 feet between the plants of *Cyamopsis* in the same row.

The land selected for these experiments had *Cyamopsis* crop during the preceding two seasons and the plants had shown a high rate of mortality due to diseases under consideration. Observations on disease-incidence in all the four series were recorded regularly till the crop was three months old. The results are shown in tables 1-9.

TABLE I. Incidence of mortality of *Cyamopsis* in mixed crops sown broadcast during 1949.

Crops	Percentage of mortality			
	Seedling rot	Root-rot and wilt of adult Plants	Severe leaf blight	Total*
Cyamopsis alone	30.7	19.2	6.0	55.9
Cyamopsis + Vigna	28.3	16.0	3.9	48.2
Cyamopsis + Ph. aconitifolius	11.0	8.6	6.9	26.5
Cyamopsis + Sorghum	24.0	12.7	6.0	42.7
Cyamopsis + soybean	28.0	16.0	3.5	47.5
Cyamopsis + Vigna + Ph. aconitifolius	25.6	7.2	3.0	25.8
Cyamopsis + Sorghum + Ph. acconitifolius	7.2	4.0	2.8	14.0
Cyamopsis + Sorghum + Ph. mungo	22.1	13.9	3.8	39.8
Cyamopsis + Ph. mungo + Ph. radiatus	23.0	15.4	3.6	42.0
Cyamopsis + Sorghum + Vigna + Ph. aconitifolius	12.6	5.6	2.9	21.1

*C. D. at 5% 1.2.

TABLE II. Incidence of mortality of *Cyamopsis* in mixed crops sown broadcast during 1950.

Crops	Percentage of mortality			
	Seedling rot	Root-rot and wilt of adult plants	Severe leaf blight	Total*
Cyamopsis alone	30.0	20.1	10.6	60.7
Cyamopsis + Vigna	30.1	19.2	4.6	53.9
Cyamopsis + Ph. aconitifolius	12.9	7.1	8.2	28.2
Cyamopsis + Sorghum	25.1	11.5	7.5	44.1
Cyamopsis + soybean	29.1	18.6	5.5	53.2
Cyamopsis + Vigna + Ph. aconitifolius	17.2	8.5	4.0	29.2
Cyamopsis + Sorghum + Ph. aconitifolius	8.5	4.6	2.1	15.2
Cyamopsis + Sorghum + Ph. mungo	22.0	12.9	5.1	40.0
Cyamopsis + Ph. mungo + Ph. radiatus	24.8	16.5	4.7	46.0
Cyamopsis + Vigna + Sorghum + Ph. aconitifolius	14.4	4.6	3.6	22.6

*C. D. at 5% 1.0

TABLE III. Incidence of mortality in *Cyamopsis* in mixed crops sown broadcast during 1951.

Crops	Percentage of mortality			
	Seedling rot	Root-rot and wilt of adult plants	Severe leaf blight	Total*
Cyamopsis	25.4	19.8	4.4	49.6
Cyamopsis + Vigna	29,9	15.5	4.0	49.4
Cyamopsis + Ph. aconitifolius	11.8	5.9	5.5	23.2
Cyamopsis + Sorghum	24,0	11.9	3.3	39.2
Cyamopsis + Soybean	25.3	20.1	3.7	49.1
Cyamopsis + Vigna + Ph. aconitifolius	15.0	8.1	0.8	23.9
Cyamopsis + Sorghum + Ph. aconitifolius.	6.9	1.2	0.2	8.3
Cyamopsis + Sorghum + Ph. mungo.	21.9	14.0	3.0	38.9
Cyamopsis + Ph. mungo + Ph. radiatus	21.7	15.0	2.9	39.6
Cyamopsis + Sorghum + Vigna + Ph. aconitifolius	7.0	5.6	1.2	13.8

*C. D. at 5% 0.8

EXPERIMENTAL RESULTS AND DISCUSSIONS

It was observed after a study of the data obtained during different years that though there were day to day differences in the rate of mortality, the ultimate periodical total of the plants killed did not vary much when compared with the mortality occurring in the corresponding period of other years. Every year the various crop mixtures stood in the same order of merit in respect of the total mortality. This might have been due to the light irrigation given to the plots in a prolonged absence of rains and due to the fact that mortality of seedlings had always been high in all the treatments.

In the broadcast-sown series (Tables 1-3) the least total mortality of *Cyamopsis* plants has occurred in beds sown mixed with *Sorghum* and *Phaseolus aconitifolius*. The difference in the percentage of total mortality from other treatments is highly significant. The mixed cropping of *Cyamopsis* with *Sorghum*, *Ph. aconitifolius* and *Vigna* has also significantly reduced the percentage of mortality. These two mixtures have given the best results, reducing the loss from about 55 percent in a pure crop to less than 20 percent. Next to these combinations are the mixtures of *Cyamopsis* with *Ph. aconitifolius* alone or with *Ph. aconitifolius* and *Vigna*. In other treatments, though the differences are significant, the losses are sufficiently high.

The seedling-rot as well as root-rot and wilt of adult plants has been least in *Cyamopsis* sown with *Sorghum* and *Ph. aconitifolius*. The mortality due to these troubles has been significantly lower in a mixed crop of *Cyamopsis*, *Sorghum*, *Vigna* and *Ph. aconitifolius* also. However, the mixture of *Cyamopsis* with *Ph. aconitifolius* alone, in spite of showing marked decrease in mortality due to seedling-rot, root-rot and wilt, gives relatively higher total mortality mainly due to an increased incidence of leaf-blight caused by *R. solani* growing over the foliage and spreading by contact between leaves. On the other hand in *Cyamopsis* sown with *Vigna and Ph. aconitifolius* the leaf-blight has been less severe, but the total mortality is high due to increase in seedling-rot, root-rot and wilt.

It is interesting to note that while the three mixtures containing *Ph. aconitifolius* as one of the components, viz., *Cyamopsis* + *Sorghum* + *Ph. aconitifolius*, *Cyamopsis* + *Vigna* + *aconitifolius*, *Cyamopsis* + *Sorghum* + *Vigna* + *aconitifolius*, have reduced the incidence of leaf-blight to an almost negligible severity, the combination of *Cyamo-psis* with *Ph. aconitifolius* alone gives a very high incidence of leaf-blight. The mortality due to leaf-blight in this mixture has been sometimes as high as in a pure crop of *Cyamopsis*. On the other hand there are some combinations, as mentioned above, which in spite of showing very high total mortality, exhibit a considerably reduced loss from leaf-blight.

These variations in the incidence of leaf-blight may be attributed to the nature of growth of the intervening crops. *Phaseolus aconitifolius* is a weak plant and usually does not attain a good height. Unless the proportion of its seed in the mixture is not much in excess of the seeds of *Cyamopsis*, it does not ensure sufficient spacing between individual plants of *Cyamopsis* due to its growth character. Consequently the *Cyamopsis* plants put up a luxuriant growth and ultimately their foliage come in contact. On the other hand crops like *Vigna*, soybeans, *Ph. mungo* and *Sorghum* attain a better height than Ph. *aconitifolius* and easily grow bushy in competition with *Cyamopsis*, sometimes suppressing the development of the latter. The plants of *Cyamopsis* remain thin, less branched and naturally a good space is created between the foliage of

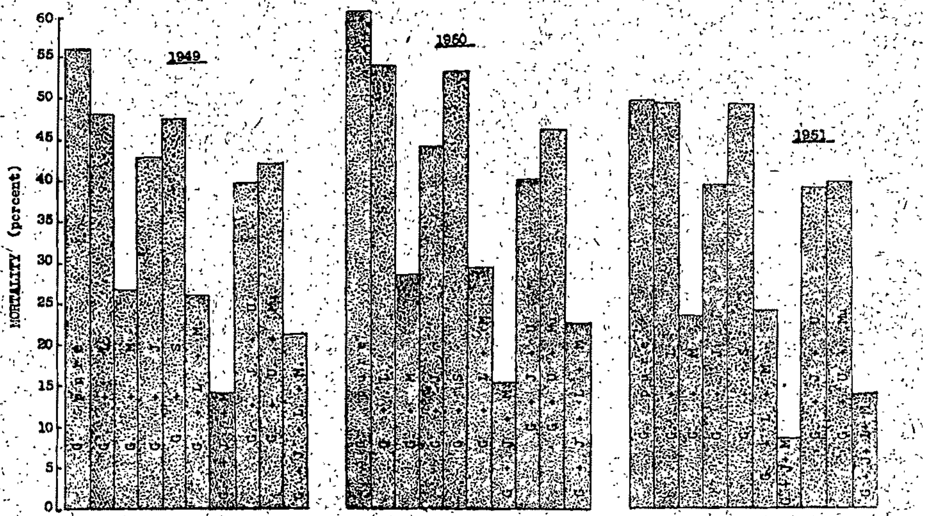


Fig. 1. Incidence of mortality in *Cyamopsis* in mixed and pure crops sown broadcast during 1949-51. G. *Cyamopsis*, L. *Vigna*, M. *Phaseolus aconitifolius*, J. *Sorghum*, S. Soybean U. *Phaseolus mungo*, m. *Ph. radiatus*.

diseased and healthy plants. This is one of the reasons why Ph. *aconitifolius* alone with *Cyamopsis* has not been able to prevent losses from leaf-blight.

Since the incidence of root-rot and wilt results solely from soil-infection, the contact between the diseased and healthy foliage or their interruption due to various intervening crops have nothing to do with the infection of roots through the soil. The mixed crop may influence the incidence of root-rot and wilt by (1) modifying the soil-temperature and soil-moisture; (2) interruptions, caused by the secondary crops, between the roots of diseased and healthy plants; (3) influence the soil-reaction; and (4) possible production of substances toxic against the fungi responsible for the diseases.

Records of soil and atmospheric temperatures as well as humidity were taken regularly during July, August, and September. The temperature was recorded twice daily. Fluctuations in the atmospheric and soil temperatures and humidity depend upon rainfall. In rainy weather the meteorological conditions in the fields with or without a crop do not show marked differences, but when the rains have stopped, the beds with standing crops always show higher humidity and relatively lower temperature, both in the soil and in the atmosphere, than in the unsown fields. However, these variations have not been much during the seedling stage of the crop. The nature of the crop standing in fields has been determining factor for the variations in temperature and humidity.

In plots with various crop mixtures the fortnightly average of the soil temperature (at a depth of 7 cm., 12 cm. and 18 cm.) during seedling stage of the plants has varied between 27.9° and 28.4° C. The lowest temperature on a single day recorded during these observations has been 25.4 C. Studies on the growth of *R. solani* and *F. coeruleum*, isolated from *Cyamopsis* under artificially controlled conditions have shown that the above mentioned range of temperature is quite suitable for a rapid growth of *R. solani* responsible for most of the deaths during seedling stage of *Cyamopsis*. The soil-moisture in pure and mixed crops during July-September has varied between 17.6 and 21.5 percent of the soil-moisture-holding capacity. Under controlled conditions of soil-moisture in pots it has been observed that both *R. solani* and *F. coeruleum* cause more than 43 percent mortality at 15 percent soil-moisture and are highly virulent upto 30 percent soil-moisture. Thus the soil-moisture has also been favourable for rapid activity by these fungi throughout the period of experiment. The atmospheric-temperature in the fields has been above 29.0° and below 35° C. It does not suit the optimum growth of *F. coeruleum* but *R. solani* can grow well at the temperatures of 29°—31° C. common to occur in fields within the above range. Thus the influence of various crop mixtures on the temperature and humidity during seedling stage of plants does not appear to have any relationship with the incidence of seedling-rot and root-rot of young plants of *Cyamopsis*.

The grown-up plants have exerted some influence in keeping the temperature of the soil and atmosphere within a range of 21.0° and 29.0° C. These temperatures have not been found to produce any adverse effect on the growth of the two fungi in question. As stated above, the soil-moisture in fields with grown-up plants too has been favourable. Here also there is no conclusive proof that mixed cropping has reduced root-rot and wilt by lowering soil and atmospheric temperatures and by increasing humidity. These results do not agree with the findings of Vasudeva (5), who has reported the possible role of mixed and inter-cropping in affecting temperature and humidity thus reducing root-rot mortality in cotton.

During laboratory experiments on the growth of *R. solani* and *F. coeruleum* on culture media at different temperatures it has been found that the best linear growth as well as dry weight of the fungal mat of *F. coeruleum* is obtained at temperatures of 25.0° and 28.0 C, while *R. solani* grows most vigorously at temperatures of 28.0° to 32.0° C, though at 25.0° C also it has shown only a slight retardation in its linear advance on solid media and in dry weight of the fungal mat on liquid media. The temperature records from fields sown with mixed crops indicate that in no case the fortnightly average of the soil-temperature has gone below 24.0° C and above 27.0° C during August and September. Thus the question of any unfavourable soil temperature for *F. coeruleum* does not arise during these two months when the vascular wilt is most common on adult plants. The mortality through wilt should have been identically influenced by the soil-temperature in fields having various crop mixtures. In plots sown with *Cyamopsis*, *Sorghum* and *Ph. aconitifolius* the average soil-temperature has varied between 25.0° and 25.8° C, the optium for *F. coerueleum*, but death of adult plants, mainly due to vascular wilt caused by this fungus, has been lowest (less than 5 per cent). On the other hand in the mixture of *Cyamopsis* with *Sorghum* and *Ph. mungo*, giving almost the same range of soil temperature as above, the mortality due to vascular wilt has been as high as ·15 per cent. Similar results are obtained with other crop mixtures also. The soil-temperature has never gone against the growth of *F. coeruleum* which accounts for the majority of deaths in later stages of plant growth. From these observations it appears that the soil temperature as affected by mixed cropping cannot be taken as an explanation for the causes of reduction in the incidence of wilt in some of the mixtures of crops with *Cyamopsis*.

Usually the temperature during August and September is not optimum for the growth of *R. solani* and this may be taken, apart from tissue-maturity of the host, as one of the reasons for low incidence of root-rot of grown up plants.

The average atmospheric temperature, which has varied between 27° and 29° C, is also not unfavourable for the growth of *R. solani* and *F. coeruleum*. Though the atmospheric temperature has no direct relationship with root-infection by these fungi

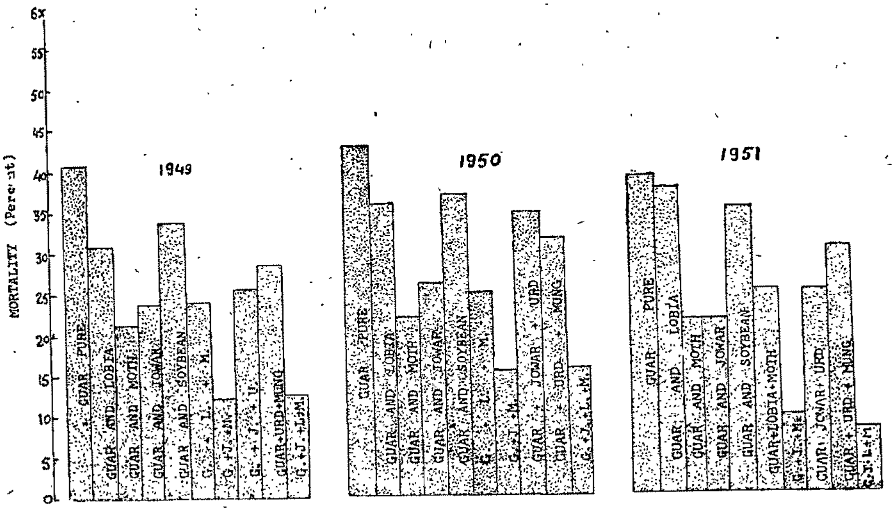


Fig. 2. Mortality in pure and mixed crops of *Cyamopsis* sown in separate rows each 2 ft. apart. Guar *Cyamopsis;* lobia *Vigna*; moth *Phaseolus aconitifolius;* jowar *Sorghum*; urd *Phaseolus mungo*; mung *Phaseolus radiatus*.

it should affect the serverity of leaf-blight caused by *R. solani* which grows from the soil on to the leaves through the stem or through direct contact. The temperature of the atmosphere in almost all the beds sown with various mixtures is optimum or nearly optimum for the growth of *R. solani*. Thus any variation in the extent of damage by leaf-blight as shown by the nature of crop mixtures does not appear to be due to any change in the atmospheric temperature.

Occasional determination of the soil pH was made during the growing season for the crop. Soil samples for this purpose were taken from a depth of 7 cm and 18 cm on the 25th July, 10th and 25th August, and 10th and 25th September. The H-ion concentration of the soil in beds with different crop mixtures has been found to vary from pH 7.7 to pH 8.4. In laboratory tests both *R. solani* as well as *F. coeruleum* have shown a good growth in media at these pH values. This factor, therefore, has also not given any possible explanation for the reduced mortality in mixed crops.

The liberation of toxins by plant roots in the neighbouring soil is so far not known. No attempt has been made during these studies to ascertain whether the roots of any of the crops included in these experiments contain or liberate such toxins. Glucosides, which on hydrolysis liberate hydrocyanic acid, are known to be present in *Sorghum* from the early stage of growth. The amount decreases with the advancing age of the plants. In mature plants this substance is present mostly in leaves. Therefore, this possibility cannot also explain the phenomenon of reduced disease-incidence in mixed cropping with *Sorghum*. The root-rot mortality in *Cyamopsis* is most common during early growth of the plant. The second phase of severe mortality, that due to wilt, starts during the 3rd and 4th weeks of the plant-growth. Had there been toxic effect of hydrocyanic acid in the soil, the mortality should have been reduced even during seedling stage in crops where *Sorghum* is one of the components of the mixture.

It is evident from the above that neither of the factors discussed herein explains the phenomenon of reduced mortality of *Cyamopsis* in a mixed crop. It appears to be certain that the reduced probability of contact between the host and the parasite due to chances of sufficient spacing in a mixed crop and the interruptions in root contacts caused by the number, seed-rate and the type of the intervening crops are the chief factors in reducing the total mortality in some of the ten mixtures tried here. This has been supported by the results obtained in the fourth series of experiments (Tables 7-9).

In the third series of experiments (Tables 4-6) where mixed seeds were sown in rows each two feet apart, the results have been almost the same as in the broadcast sown crops.

TABLE IV. Incidence of mortality in *Cyamopsis* sown pure or in mixture with other crops in rows two feet apart during 1949.

Crops	Percentage of mortality			
	Seedling rot	Root-rot and wilt of adult plants	Severe leaf blight	Total*
Cyamopsis alone	26.6	20.0	4.5	51.1
Cyamopsis + Vigna	28.5	18.0	1.9	48.4
Cyamopsis + Ph. aconitifolius	15.8	6.2	3.5	25.5
Cyamopsis + Sorghum	25.0	11.9	0.4	37.3
Cyamopsis + Soybean	26.5	18.5	3.0	48.0
Cyamopsis + Vigna + Ph. aconitifolius	18.5	16.3	2.0	36.8
Cyamopsis + Sorghum + Ph. aconitifolius	12.4	2.0	0.1	14.5
Cyamopsis + Sorghum + Ph. mungo	21.4	15.5	1.9	38.8
Cyamopsis + Ph. mungo + Ph. radiatus	20.3	17.1	2.8	40.2
Cyamopsis + Sorghum + Vigna + Ph. aconitifolius	13.0	8.3	0.2	21.5

*C. D. at 5% 1.7

TABLE V. Incidence of mortality in *Cyamopsis* sown pure or in mixture with other crops in rows two feet apart during 1950.

Crops	Percentage of Mortality			
	Seedling rot	Root-rot and wilt of adult plants	Severe leaf blight	Total*
Cyamopsis alone	27.1	18.0	6.6	51.7
Cyamopsis + Vigna	32.0	14.0	2.4	48.4
Cyamopsis + Ph. aconitifolius	15.0	6.8	3.9	25.7
Cyamopsis + Sorghum	26.4	10.8	1.1	38.3
Cyamopsis + soybean	28.9	15.5	3.6	48.0
Cyamopsis + Vigna + Ph. aconitifolius	19.7	8.9	2.8	31.4
Cyamopsis + Sorghum + Ph. aconitifolius	15.8	3.6	0.2	19.6
Cyamopsis + Sorghum + Ph. mungo	22.0	15.7	2.7	40.8
Cyamopsis + Ph. mungo + Ph. radiatus	21.1	19.0	3.3	43.4
Cyamopsis + Sorghum + Vigna + Ph. aconitifolius	12.8	9.0	0.4	22.2

*C. D. at 5% 1.4

TABLE VI. Incidence of mortality in *Cyamopsis* sown pure or in mixture with other crops in rows two feet apart during 1951.

Crops	Percentage of mortality			
	Seedling rot	Root-rot and wilt of adult plants	Severe leaf blight	Total*
Cyamopsis alone	26.4	18.7	2.3	47.4
Cyamopsis + Vigna	27.0	20.0	2.9	47.9
Cyamopsis + Ph. aconitifolius	16.2	5.8	1.9	23.9
Cyamopsis + Sorghum	23.8	10.8	0.0	34.6
Cyamopsis + soybean	26.7	14.9	3.2	44.8
Cyamopsis + Vigna + Ph. aconitifolius	17.0	3.9	2.9	23.8
Cyamopsis + Sorghum + Ph. aconitifolius	11.7	2.2	0.0	13.9
Cyamopsis + Sorghum + Ph. mungo	22.0	13.9	2.0	37.9
Cyamopsis + Ph. mungo + Ph. radiatus	19.5	17.9	3.0	40.4
Cyamopsis + Sorghum + Vigna + Ph. aconitifolius	12.6	5.9	0.1	18.6

*C. D. at 5% 0.8

TABLE VII. Incidence of mortality in *Cyamopsis* in pure and mixed crops sown in separate rows each two feet apart with a distance of two feet between plants of *Cyamopsis*. 1949

Crops	Percentage of mortality			
	Seedling rot	Root-rot and wilt of adult plants	Severe leaf blight	Total*
Cyamopsis alone	26.1	11.8	2.6	40.5
Cyamopsis + Vigna	23.0	6.4	1.0	30.4
Cyamopsis + Ph. aconitifolius	17.6	3.1	0.2	20.9
Cyamopsis + Sorghum	20.6	3.0	0.0	23.6
Cyamopsis + soybean	21.2	10.3	2.1	33.6
Cyamopsis + Vigna + Ph. aconitifolius	20.3	3.3	0.0	23.7
Cyamopsis + Sorghum + Ph. aconitifolius	11.0	0.8	0.0	11.8
Cyamopsis + Sorghum + Ph. mungo	19.0	4.9	1.4	25.3
Cyamopsis + Ph. mungo + Ph. radiatus	20.0	6.2	2.0	28.3
Cyamopsis + Sorghum + Vigna + Ph. aconitifolius	12.1	0.2	0.0	12.3

*C. D. at 5% 1.8

TABLE VIII. Incidence of mortality in *Cyamopsis* in pure and mixed crops sown during 1950 in separate rows each two feet apart with a distance of two feet between the plants of *Cyamopsis*.

Crops	Percentage of mortality			
	Seedling rot	Root-rot and wilt of adult plants	Severe leaf blight	Total*
Cyamopsis alone	30.2	10.2	2.0	42.4
Cyamopsis + Vigna	24.0	10.0	1.2	35.2
Cyamopsis + Ph. aconitifolius	17.9	3.2	0.4	21.5
Cyamopsis + Sorghum	23.7	2.0	0.0	25.7
Cyamopsis + soybean	24.0	10.7	1.8	36.5
Cyamopsis + Vigna + Ph. aconitifolius	21.4	3.0	0.0	24.4
Cyamopsis + Sorghum + Ph. aconitifolius	14.6	0.5	0.0	15.1
Cyamopsis + Sorghum + Ph. mungo	23.7	9.0	1.5	34.2
Cyamopsis + Ph. mungo + Ph. radiatus	20.5	8.0	2.5	31.0
Cyamopsis + Sorghum + Vigna + Ph. aconitifolius	14.3	0.3	0.1	14.7

*C. D. at 5% 1.2

TABLE IX. Incidence of mortality in *Cyamopsis* in pure and mixed crops sown during 1951 in separate rows each two feet apart with a distance of two feet between plants of *Cyamopsis*.

Crops	Percentage of mortality			
	Seedling rot	Root-rot and wilt of adult plants	Severe leaf blight	Total*
Cyamopsis alone	24.2	13.0	1.8	38.2
Cyamopsis + Vigna	23.7	12.3	1.0	37.2
Cyamopsis + Ph. aconitifolius	17.4	4.6	0.0	21.0
Cyamopsis + Sorghum	15.7	5.2	0.0	20.9
Cyamopsis + soybean	23.2	10.0	1.2	34.4
Cyamopsis + Vigna + Ph. aconitifolius	21.1	3.3	0.0	24.4
Cyamopsis + Sorghum + Ph. aconitifolius	8.3	1.0	0.0	9.3
Cyamopsis + Sorghum + Ph. mungo	13.7	10.5	0.3	24.5
Cyamopsis + Ph. mungo + Ph. radiatus	20.4	7.5	1.8	29.7
Cyamopsis + Sorghum + Vigna + Ph. aconitifolius	6.6	1.0	0.0	7.6

*C. D. at 5% 1.9

The results of the fourth series (Tables 7-9), which aimed at the finding out of the effect of inter-cropping on the disease-incidence, give additional support to the assertion that the reduction in mortality in mixed crops is due to spacing and interruptions in root-contacts. In this experiment the rows of *Cyamopsis* were intervened by rows of the secondary crops of a particular mixture. Each row was two feet apart and the plants of *Cyamopsis* within the same row were kept at a distance of two feet from each other. This created, according to the nature of the mixture, a distance of 4-8 feet between two rows of *Cyamopsis*. The disease-incidence has been considerably reduced as compared to that in crops sown broadcast. Even in those mixtures which, in broadcast sowing, give a high rate of mortality, the incidence of wilt has been significantly lowered. The differences in the total mortality in different mixtures have been highly significant. The incidence of mortality in seedlings has mostly been high and in many mixtures the percentages are almost similar. The differences in the figures for mortality are most apparent when the plants have advanced in age. The records of temperature and moisture in these plots show that these factors have rarely been unfavourable for *R. solani* and *F. coeruleum.*

The yield of fodder in the second series of plots for different years has been shown in table 10. The highest yield of fodder has been obtained when *Cyamopsis*, *Sorghum*, *Vigna* and *aconitifolius* are sown together. It gives an increase of more than 130 maunds over the yield obtained from a pure crop of *Cyamopsis*. *Cyamopsis*, *Sorghum* and *Ph. aconitifolius*; *Cyamopsis*, *Vigna* and *Ph. aconitifolius*; or *Cyamopsis*, *Sorghum* and *Ph. mungo* have also shown considerable increase in fodder yield as compared to pure crop of *Cyamopsis*.

TABLE X. Total yield of fodder in pure and mixed crops of *Cyamopsis* during 1949-51.

Crops	Yield of fodder (maunds).		
	1949	1950	1951
Cyamopsis alone	150.7	144.2	159.1
Cyamopsis + Vigna	240.5	237.5	210.0
Cyamopsis + Ph. aconitifolius	175.6	220.4	164.0
Cyamopsis + Sorghum	190.3	249.7	219.6
Cyamopsis + Soybean	185.8	170.0	204.2
Cyamopsis + Vigna + Ph. aconitifolius	276.3	240.1	270.0
Cyamopsis + Sorghum + Ph. aconitifolius	283.5	269.2	255.5
Cyamopsis + Sorghum + Ph. mungo	212.5	157.5	160.0
Cyamopsis + Vigna + Sorghum + Ph. aconitifolius	320.0	270.0	298.8

SUMMARY

A study of the effects of mixed and inter-cropping on the incidence of root-rot and wilt of *Cyamopsis psoralioides* DC., caused by *Rhizoctonia solani* Kuhn. and *Fusarium coeruleum* (Lib.) Sacc., was carried out at Kanpur during 1949-51.

Six crops in ten combinations were tried with it. The incidence of mortality is reduced to about one-third when the crop is grown with *Sorghum* and *Ph. aconitifolius* or with *Sorghum, Vigna*, and *Ph. aconitifolius*. Combinations with *Ph. aconitifolius* alone or with *Vigna* and *Ph. aconitifolius* have also given good results.

There is no evidence that the reduced mortality in mixed crops is due to modified soil or air-temperature and humidity or due to any change in the soil reaction. There is no support in these experiments for the possibility of production of hydrocyanic acid in the soil when the crop is sown with *Sorghum*. Spacing, resulting in reduced probability of contact between the host and the parasite as well as the barriers caused by the roots of secondary crops in the mixture, between the roots of healthy and diseased plants of *Cyamopsis* appear to be the main reasons for reduced incidence of root-rot and wilt.

ACKNOWLEDGMENTS

This work was carried out in a scheme partly financed by the U. P. Government Scientific Research Committee. The author is thankful to Dr. B. L. Sethi, Principal, Govt. Agricultural College, Kanpur for facilities, to Dr. B. Singh, Plant Pathologist to the Govt. of Uttar Pradesh, who has been very kind to supervise the work and to Dr. T. R. Mehta for going through the manuscript.

REFERENCES

1. GARRETT, S. D. 1944. Root Disease Fungi. Chronica Botanica Co. Waltham, Mass., U. S. A. p. 99.
2. HANSFORD, C. G. 1940. Vascular diseases of cotton in Uganda. *E. Africa agric. J.*, **5** : 279-282.
3. SINGH, R. S. 1951. Root-rot of guar. *Science and Culture*, **17** : 131-133.
4. TAUBENHAUS J. J. and EZEKIEL, W. W. 1931. Cotton root rot and its control. *Bull. Texas agric. Exp. Sta.*, 423.
5. VASUDEVA, R. S. 1941. Studies on the root-rot disease of cotton in the Punjab XI. Effect of mixed cropping on the incidence of the disease. *Indian J. agric. Sci.*, **11** : 879-891.
6. VASUDEVA, R. S. and ASHRAF, M. 1939. Studies of the root rot disease of cotton in the Punjab VII. Further investigations of factors influencing incidence of the disease. *Indian J. agric. Sci.*, **9** : 595-608.

ROOT-ROT AND WILT OF *CYAMOPSIS PSORALIOIDES* IN RELATION TO DATE OF SOWING

By R. S. Singh, *Lecturer in Plant Pathology, Govt. Agricultural College, Kanpur.*

Introduction

The periodicity in the virulence of various plant pathogens is well marked in the case of soil-borne diseases. Soil-temperature, soil-moisture and the age of the plants at which they are most susceptible, are the chief factors which influence this periodicity in the intensity of root-rot and wilt. It has been observed under field conditions (1) that these environmental factors can be modified by suitable alterations in the date of sowing, thus enabling the plants to pass over the critical period with minimum damage from root-rot and wilt.

Root-rot and wilt of clusterbeans, *Cyamopsis psoralioides* DC., (*guar*) caused by *Rhizoctonia solani* Kuhn. and *Fusarium coeruleum* (Lib.) Sacc., have been of common occurrence in Uttar Pradesh for the last several years (2). The plants die of seedling-rot, caused by *R. solani* or due to root-rot and wilt caused by *R. solani* and *F. coeruleum* respectively. Plants also suffer from defoliation either as a result of root-rot and wilt or due to leaf-blight caused by *R. solani* growing from the soil on to the leaves and spreading over the foliage through contact between healthy and diseased leaves. Studies on these diseases were carried out during the years 1947-53 at Kanpur.

During the period of five months (April-August) when this crop is usually sown for fodder in different parts of Uttar Pradesh, the soil-temperature and moisture in the fields vary over a very wide range. It has been found that the severity of root-rot and wilt fluctuates according to the season and age of the plants. Experiments were undertaken to find the effect of sowing the crop at different intervals, thus modifying the above mentioned conditions, on the incidence of mortality due to seedling-rot, root-rot, wilt and leaf-blight.

MATERIAL AND METHODS

The experiments were laid out in randomised blocks on a piece of land which had the same crop during the preceding year, showing about 12 percent mortality due to seedling-rot, root-rot and wilt. The size of beds was 40×20 feet, with 2 feet distance between each bed. The beds were sown on different dates at intervals of 13-15 days between 1st May and 28th August. Equal quantity of seed was sown in 20 feet-long rows, each two feet apart. Each treatment (date of sowing) was replicated thrice and the experiments were repeated during 1949-51.

Inoculum was prepared by growing pure culture of *R. solani* and *F. coeruleum*, isolated from diseased plants, on maize-meal-soil medium for one month. The soil in rows was mixed with the inoculum six days prior to sowing of the seed.

Ten days after sowing all the plants in each row were counted. Observations on mortality of plants were recorded at regular intervals throughout the crop season. Since a number of other experiments on effect of cultural practices on the incidence of said diseases were in progress simultaneously, it was not practicable in each experiment to critically study the mortality due to various phases (seedling-rot, root-rot, wilt and leaf-blight) of the disease-complex in question. In this experiment the dead plants were pulled out and counted on each day of observation and the total number of dead plants calculated at the end of the twelfth week after emergence.

EXPERIMENTAL RESULTS AND CONCLUSIONS

The rate of mortality in different treatment during 1949, 1950 and 1951 are shown in tables 1-3. The statistical analysis of the data for total mortality shows that the differences in many of the treatments are highly significant. The maximum number of plants have been killed in crops sown on the 28th July. There is significantly low mortality in crops sown on the 29th June and

Table I. Effect of changing the date of sowing on the incidence of mortality due to seedling-rot, root-rot, wilt and leaf-blight during 1949.

Time of observation (weeks after emergence)	Percentage of mortality								
	Date of sowing								
	May			June		July		August	
	1	16	31	15	29	14	28	12	27
1	1.1	0.6	3.1	2.5	6.8	7.5	7.9	6.7	7.9
2	1.3	2.7	2.8	5.1	5.6	6.5	8.7	4.8	6.3
3	0.8	4.9	2.5	5.3	3.7	4.5	1.4	4.5	1.0
4	3.9	1.4	1.6	2.7	1.4	2.6	0.9	2.7	3.0
5	4.1	0.8	3.6	0.8	2.7	2.0	5.9	3.9	3.6
6	0.8	0.8	1.9	2.9	1.2	3.1	6.7	2.8	2.0
7	0.6	0.8	1.2	2.1	2.3	1.7	6.0	2.8	2.3
8	0.7	0.4	1.3	2.7	1.5	2.6	4.5	0.7	0.4
9	0.9	0.5	0.9	1.8	2.9	0.5	1.9	0.3	1.0
10	0.5	0.6	0.8	1.3	2.9	0.7	0.5	0.3	0.0
11	0.1	0.5	1.0	0.0	0.2	0.4	0.3	0.4	0.0
12	0.2	0.3	0.0	0.6	0.5	0.3	0.0	0.3	0.1
Total*	15.0	14.3	20.7	27.8	31.7	32.4	44.7	27.2	27.6

*C. D. at 5% 1.0

Table II. Effect of changing the date of sowing on the incidence of mortality due to seedling-rot, root-rot, wilt and leaf-blight during 1950.

Time of observation (weeks after emergence)	Percentage of mortality								
	Date of sowing								
	May			June		July		August	
	1	15	30	15	29	14	28	12	28
1	0.4	0.4	1.0	0.3	3.8	4.3	7.6	6.6	4.8
2	0.3	1.6	1.4	2.7	5.9	7.9	8.0	3.1	2.3
3	2.3	2.0	2.0	2.9	3.7	7.1	8.3	2.2	0.8
4	2.3	2.1	1.8	3.4	5.9	4.4	3.9	0.0	1.0
5	0.5	1.2	2.6	3.1	5.8	4.5	3.1	0.5	0.6
6	3.2	0.9	2.8	2.5	3.3	2.6	3.4	0.3	0.2
7	0.2	1.5	2.3	2.0	3.7	3.2	3.5	0.4	0.3
8	0.1	0.6	2.4	1.7	2.1	0.6	0.8	0.0	0.0
9	0.1	0.1	0.7	0.3	0.5	0.0	1.3	0.0	0.1
10	0.0	0.2	0.3	0.4	0.0	0.0	0.1	0.0	0.0
11	0.1	0.1	0.1	0.2	0.3	0.1	0.0	0.0	0.1
12	0.2	0.1	0.2	0.3	0.3	0.1	0.0	0.0	0.0
Total*	9.7	10.8	17.6	20.8	35.3	34.8	40.0	13.1	10.2

*C. D. at 5% 1.3

TABLE III. Effect of changing the date of sowing on the incidence of mortality due to seedling-rot, root-rot, wilt and leaf-blight during 1951.

Time of observation (weeks after emergence)	Percentage of mortality Date of sowing May			June		July		August	
	2	16	31	16	30	15	29	13	28
1	0.8	0.5	2.0	1.9	3.0	6.9	9.0	5.1	3.4
2	0.2	1.2	2.1	4.0	6.7	6.5	7.3	2.4	4.3
3	2.9	3.4	2.6	4.1	4.3	3.0	5.8	0.9	2.0
4	1.2	1.9	2.5	1.0	3.3	2.8	3.7	1.0	2.0
5	4.2	1.0	2.0	3.5	3.6	3.8	3.0	4.6	1.1
6	3.1	1.4	2.3	2.2	2.8	2.0	3.9	2.6	1.5
7	0.2	0.8	1.9	3.0	2.5	1.1	3.0	2.3	1.9
8	0.0	1.5	1.7	1.1	1.0	2.0	0.5	2.0	2.3
9	0.7	1.0	0.5	1.9	0.0	1.5	0.3	0.5	1.9
10	0.1	0.5	0.8	1.2	1.5	0.4	0.6	0.0	1.1
11	0.0	0.8	0.5	0.3	0.2	0.0	0.0	0.3	0.0
12	0.0	0.2	0.5	0.6	0.0	0.2	0.0	0.1	0.0
Total*	13.4	14.2	19.4	24.8	28.9	30.2	37.1	21.8	21.5

*C. D. at 5% 1.4

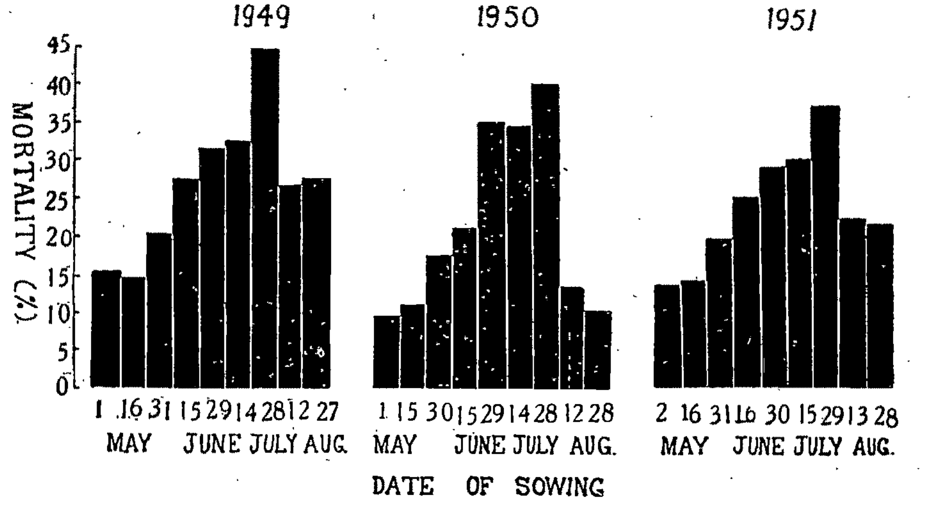


Fig. 1. Effect of different dates of sowing on the incidence of mortality in *Cyamopsis psoralioides*.

14th July, as compared with crop sown on the 28th July. The difference in the figures for total mortality in crops sown on the

29th June and 14th July is insignificant. The damage is still less in the crops sown on the 15th June. The mortality has been least of all the treatments in crops sown during May which are significantly better than the crops sown later.

In most of the treatments (sowing dates) the young plants have been subjected to a very high and rapid rate of mortality, which falls off as the age of plants goes up. The percentage of damage in a single week is considerably high during later June, July and August. In the crops sown by the end of July, which have shown the highest total percentage of total mortality, the peak figures occur during early period of the plant growth *i. e.*, during the last week of July and August. Similarly crops sown in August usually show the maximum damage during the first week after emergence *i. e.* by the end of August. In the case of crops sown earlier than the 14th of July the percentage of mortality is not as heavy in the first week after emergence as during the later period.

The variations in the mortality figures in different sowings are well marked upto the fourth week after emergence. During the fifth, sixth and seventh weeks the variations are less pronounced. The major portion of damage has usually been done on young plants due to seedling-rot and root-rot and less during latter period on mature plants due to wilt. The age of the plants as well as season and consequently the date of sowing appear to have greater effect on root-rot and seedling-rot rather than on wilt, as is evidenced by the amount of variation noticed in the mortality of young and adult plants.

The data obtained during these experiments indicate that one of the factors affecting the rate of mortality is the age of plants at the time, when other environmental factors are favourable for the fungi, especially *R. solani*, which is mainly responsible for seedling-rot and root-rot of adult plants. As is evident from the data in Tables 1-3 and fig. 3, the mortality is most rapid during seedling stage of the plant-growth or soon after that. This is due to softness of the tissues favourable for the rapid infection by *R. solani*. As the tissues gain maturity, the chances of infection by *R. solani* become less. The seedling-rot phase is gradually changed into root-rot phase when mostly the cortical tissues of the root are disintegrated, resulting in the appearance of symptoms of wilt on the aerial parts of the host. However, even this phase does not last long and in adult plants (6-12 weeks old) disintegration of the root tissues is not as common as the presence of the fungal hyphae in the normal looking vascular tissues. The vascular wilt has mostly been observed on mature plants and indicates that susceptibility to infection by *F. coeruleum* increases, upto a certain limit, with age of the plant. It is also possible that during early growth of the host the activity of *F. coeruleum* is masked by that of *R. solani*.

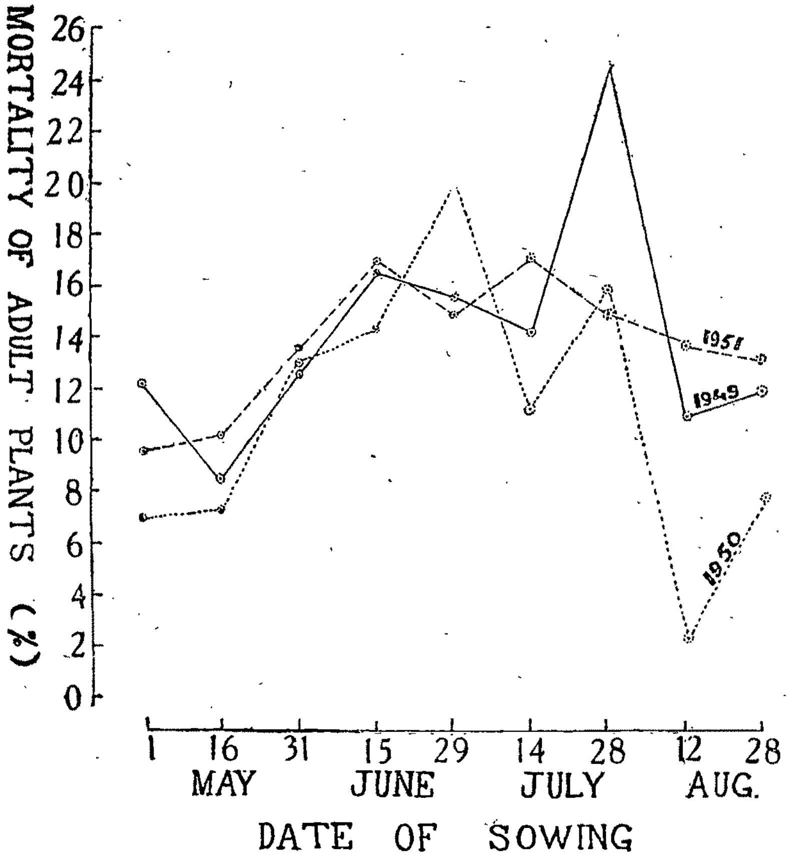


Fig. 7. Effect of date of sowing on mortality of mature *Cyamopsis psoralioides* plants due to root-rot, wilt and leaf blight.

Another important factor which has been operating in determining the relative incidence of mortality in different sowings appears to be the soil-temperature and soil-moisture during different stages of the plant growth. The low mortality in crops sown during May has been mainly because of reduced incidence of seedling-rot. Apparently the soil-conditions during this period have not been favourable for *R. solani.* As the season has advanced the conditions—soil-temperature as affected by soil-moisture increasing or decreasing according to irrigation or rainfall—have come down to normal for this fungus. Consequently the rate of seedling-mortality has increased in the crops sown during June or later. The damage through vascular wilt has not been affected much in different sowings except in the crops sown upto 31st May where there is less mortality amongst adult plants. This appears to be due to unfavourable soil-temperature for *F. coeruleum* during later part of May and during June.

Though the alteration in the date of sowing has given conclusive proof that early sowing of the crop is useful in reducing the mortality to less than one-third of what is met with in crops

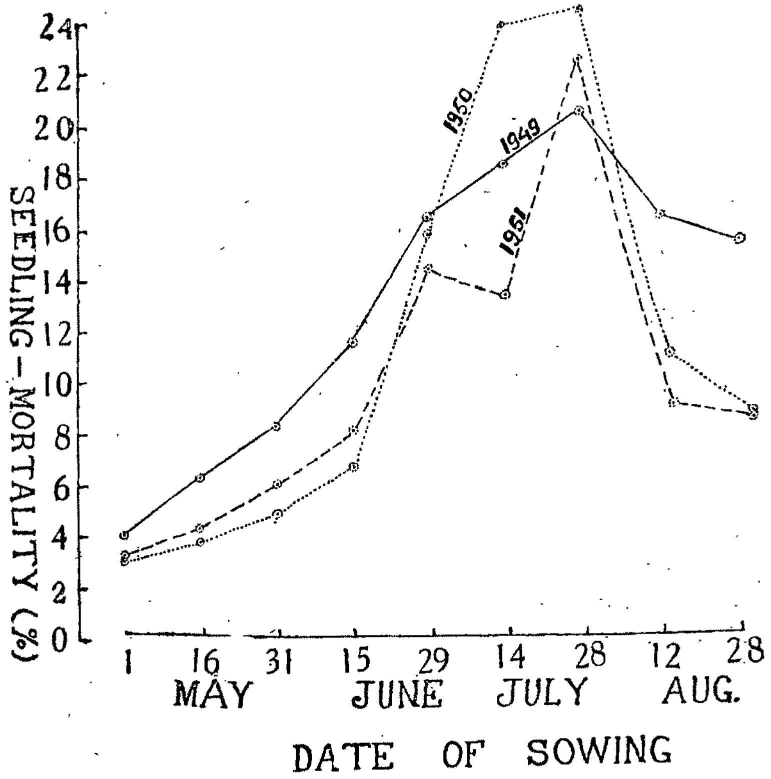


Fig. 3. Effect of date of sowing of mortality in seedling of *Cyamopsis psoralioides.*

sown after the break of monsoons (July), it is evident that for practical purposes this shifting of the date may not be advantageous. Early sowing of the crop during May and June can be practised only in irrigated tracts, where facilities exist for watering of the fields at the time of seed-bed preparation and for subsequent irrigation. Most of the regions of this state do not possess these facilities. The normal sowing of the crop is usually taken up with the break of monsoons (July) but the experiments have shown that the alterations in the sowing date during July do not reduce mortality. In early sown crops the plants mature during August and September and it has been found that the wilting caused by *F. coeruleum* may be quite severe even if the pods on four months old plants are in ripening stage. Thus it is likely that if the crops escape damage from *R. solani* during young stage they may suffer heavily from *F. coeruleum* during latter part of the plant growth, thus affecting the yield of grains. The fact that two fungi, altogether different in their habit and affecting the plants more severely at two different stages of growth, are responsible for the mortality makes the problem complicated.

SUMMARY

Root-rot and wilt of *Cyamopsis psoralioides* DC. caused by *Rhizoctonia solani* Kuhn. and *Fusarium coeruleum* (Lib.) Sacc., which are common in Uttar Pradesh, has shown certain degree of periodicity in its virulence.

Experiments were carried out on a field scale during 1949-51 to find out the effects of different dates of sowing on the incidence of mortality due to these fungi. The crops were sown on nine dates at intervals of 13-15 days between 1st. May and 28th. August.

The total mortality of plants is lowest in crops sown during first and second week of May and highest in crops sown during July. Early sowing has proved better than the sowing carried out during July in respect of the disease-incidence. However, this advantage is restricted to only the irrigated tracts.

ACKNOWLEDGMENTS

The author is thankful to Dr. B. L. Sethi, Principal, Government Agricultural College, Kanpur and to Dr. B. Singh, Plant Pathologist to the Government of Uttar Pradesh, for facilities and supervising the work, which was carried out under a Scheme partly financed by the U. P. Government Scientific Research Committee. Thanks are also due to Dr. T. R. Mehta, Professor of Botany, Government Agricultural College, Kanpur for going through the manuscript.

REFERENCES

1. PADWICK, G. WATTS and BHAGWAGAR, R. R. 1943. Wilt of gram in relation to date of sowing. *Indian J. agric. Sci.*, **13** : 289.
2. SINGH, R. S. 1951. Root-rot of 'guar' *Science and Culture,* **17** : 131-133.

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

II.—On a Collection of Odonata.

By Santokh Singh, M. Sc. and H. N. Baijal, M. Sc., *Research Associates, School of Entomology, St. John's College, Agra.*

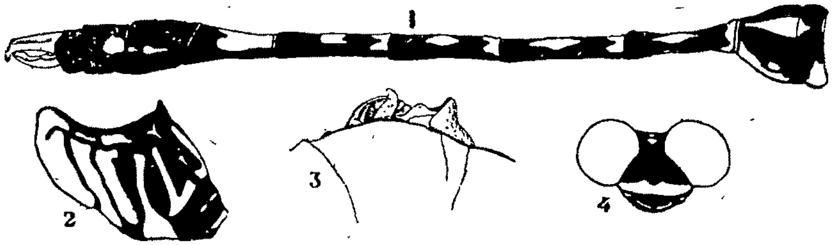
We thank Prof. Dr. M. S. Mani for placing this small but interesting collection of Odonata, made in the course of an insect survey of the Himalayas, at our disposal. We are also indebted to him for guidance. The type specimens of the new forms described here are deposited in the Collections of the Zoological Survey of India, Indian Museum, Calcutta.

Suborder Anisoptera

Superfamily Aeschnoidea

Family Gomphidae

Onychogomphus garhwalicus, sp. nov.

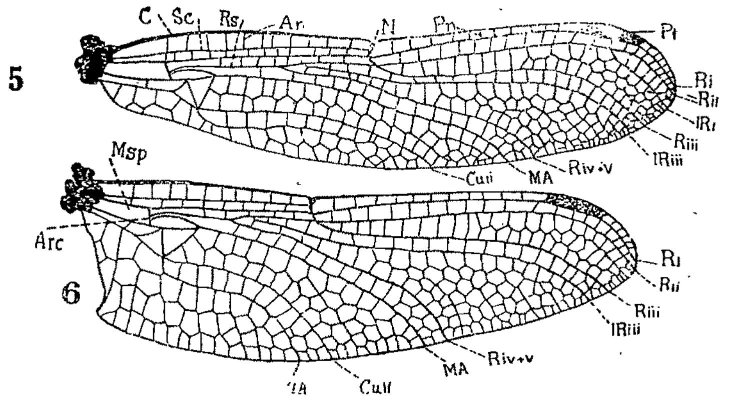


Onychogomphus garwhalicus, sp. nov. - Male : Fig. 1. Abdomen. Fig. 2. Pterothorax. Fig. 3. Genitalia. Fig. 4. Head.

Male.—Abdomen 37 mm. Hindwing 41 mm. Anal appendages 3 mm. *Head* (fig. 4) with labium bright yellow; labial palpi black. Labrum greenish-yellow, with a black stripe on anterior border; base of mandible greenish-yellow. Occiput small, black, with yellow spot in the middle. Frons yellowish-green, bordered broadly black in front and narrowly behind. Clypeus brown and post clypeus black with yellowish-green round spots on either sides above. *Prothorax* black. *Pterothorax* (fig. 2) yellowish-green, marked with black stripes as in figure. *Legs* black; fore femora with a white patch beneath and hind femora with yellow stripe outside, with a row of closely set robust, short spines. *Wing* (figs. 5-6) hyaline, costa dark brown nearly upto the pterostigma; latter brownish-black, well braced with four cells. Antenodal nervures and arculus brown; tornus angulated, base of hindwing oblique and deeply excavate; anal triangle four-celled; arculus opposite the second antenodal nervure; only two transverse nervures between sectors of arc and the bifurcation of Rs in fore wing; in hind wing only one; discoidal cell entire in fore and hind wing; hypertrigone and subtrigone entire in both the wings; nodal index : $\frac{10-10}{9-9}$, $\frac{11-11}{11-13}$ in hind wing; $\frac{12-13}{13-11}$, $\frac{11-11}{12-11}$ fore wing; pterostigma swollen in the middle, covering about 3 cells. One row of cells between R_i and R_{ii} ; only 3 cells between 1A and Cu_{ii} at wing margin. *Abdomen* (fig. 1) black, marked with yellow as in figure; anal appendages superior light brown, apically darker; inferior light brown; superior appendages converging and rather sharply turned down and compressed apically; inferior appendages cleft near to base, curved rather abruptly at their middle so that their apices lie before the apices of the superior appendages, with a stout basal obtuse tooth and an acute tooth subapically. *Genitalia* as in fig. 3.

---

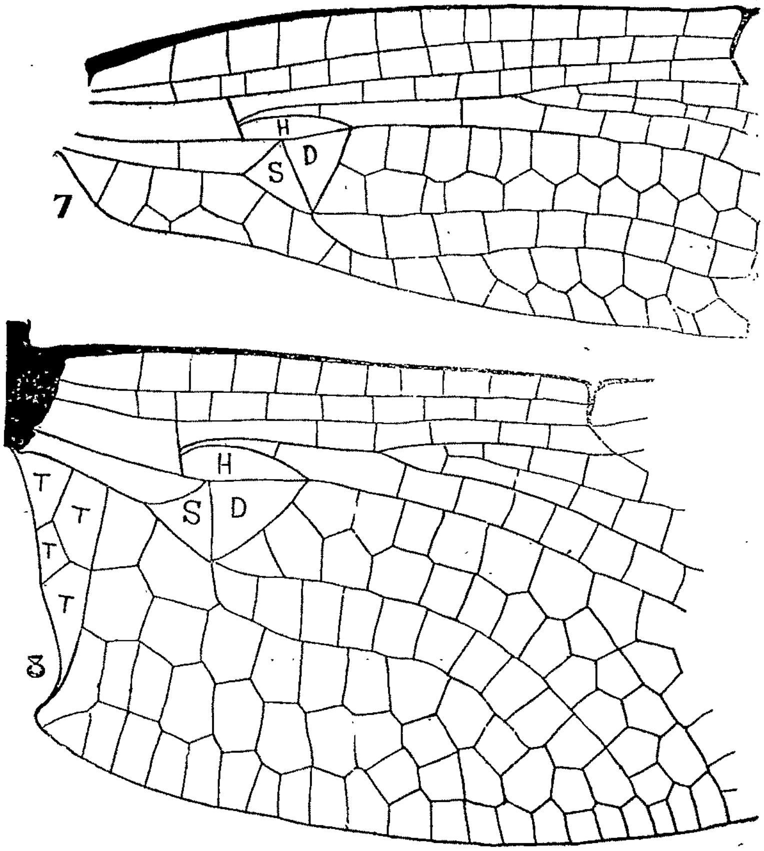
*Contribution No. 45 from the School of Entomology, St. John's College, Agra; published with the permission of the Professor of Zoology & Entomology.



Onychogomphus garhwalicus, sp. nov. Male : FIG. 5. Fore wing. FIG. 6. Hind wing.

Holotype 1 male. Chakrata Ranges, 8000 ft. River Jamuna ravines. Coll. Koshy Mathew, September 1953.

This species is readily distinguished from *Onychogomphus duaricus* Fraser[1] by the yellow marking in the middle of occiput, prothorax black, without lateral yellow spots, pterothorax yellowish-green and differently striped black, legs black, fore femora with white patch beneath and hind femora with yellow stripe on outside, wing not tinted pale amber yellow, pterostigma about 3 cells, one row of cells between Ri and Rii, only 3 cells between 1A and Cuii at margin, anal appendages light brown, inferior cleft near to base, with a stout obtuse tooth basally and an acute tooth subapically and in the characters of the male genitalia.



Onychogomphus garhwalicus sp. nov. Male : FIG. 7. Base of Fore wing, enlarged. FIG. 8. Base of Hind wing, enlarged.

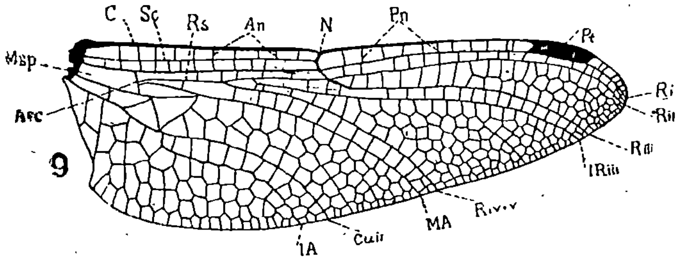
---

[1] FRASER, F. C. 1934. Fauna Brit. India, Odonata, **2** : 245.

Anisogomphus bivittatus (Selys)

1857. *Gomphus bivittatus*, SELYS, *Bull. Acad. Belg.*, **21**(2) : 46.
1890. *Anisogomphus bivittatus*, KIRBY, *Cat. Odonata*, p. 69.
1926. *Anisogomphus bivittatus*, FRASER, *J. Bombay nat. Hist. Soc.*, **31** : 425-426, fig. (3)8, fig. 5a, pl. ii, fig. 4.
1934. *Anisogomphus bivittatus*, FRASER, *Fauna Brit. India*, Odonata, **2** : 192, fig. 61a.

We have before us one male (Fig. 9) from Chakrata Range, R. Jamuna ravines, 8000 ft, coll. Koshy Mathew, 21-x-1953, which agrees well with the description of the species. This species has been previously recorded from the Kumaon and eastern Himalayas. The present record extends its distribution to the western parts of the Himalayas.

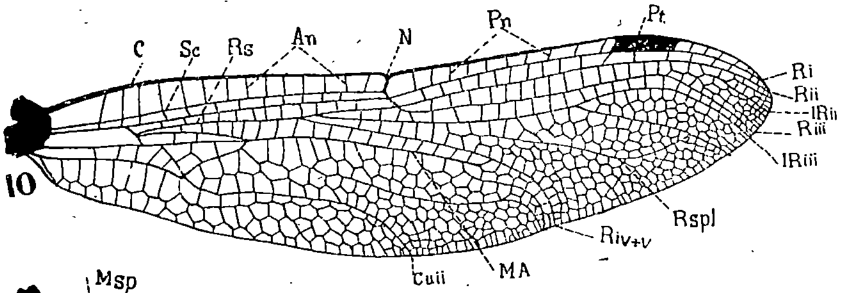


Anisogomphus bivittatus (Selys) Male : Fig. 9. Hind wing.

Family Aeschnidae

Anaciaeschna kashmirense, sp. nov.

Male.—Abdomen 42 mm. *Hind wing* 41 mm. *Head* with



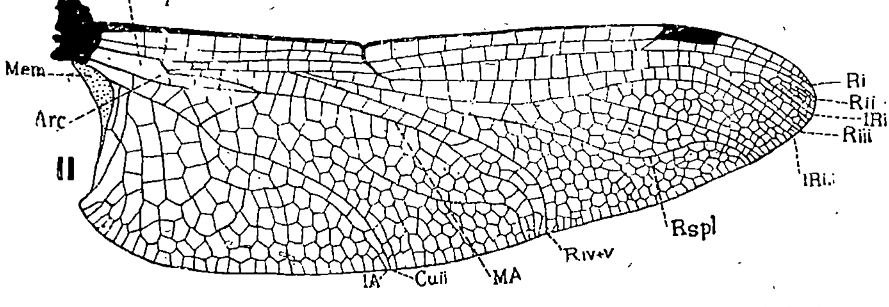
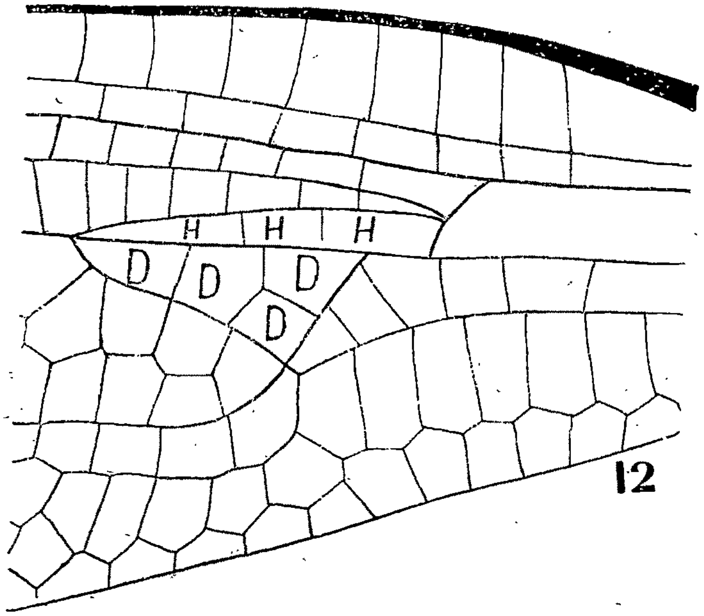


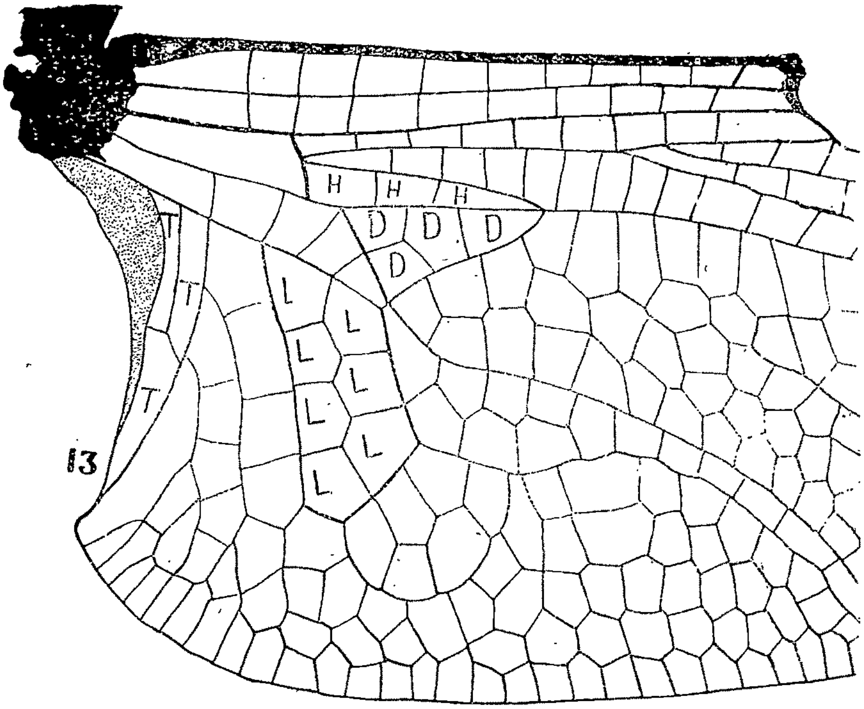
FIG. 10. *Anaciaeschna kashmirense*, sp. nov. Male : Fore wing. FIG. 11. Hind wing.

the eyes globular, labium and labrum light brown, the latter with anterior border black, clypeus light brown, frons and postclypeus pale yellow, mandible black apically, brown basally, occiput small, light brown. *Prothorax* dark brown, posterior lobe simple, rounded and fringed with long setae. *Pterothorax* robust, moderately densely clothed with long grey setae, mid-dorsal carinal suture very dark brown; antehumeral region brown, humeral suture dark ferrugineous brown; mesepimeron dark rusty beneath and pale blue above; metepimeron pale blue and metepisternum brown, with an obscure patch beneath. *Legs* black to dark reddish-brown basally in front, with minute spines. *Wing* (fig. 10-13) hyaline, with obscure pale amber-yellow tint basally near the anterior margin; discoidal cells approximately equal, elongate parallel to the axis of wing, with 4 cells; its base far distal of the arculus but about the same distance in the fore and hind wings; subtrigone well formed, with 2 cells; anal loops 7-celled, just posterior to subtrigone and discoidal cell; anal triangle well formed, very long, narrow, with 3 cells; proximal nervure in the discoidal cell of the fore and hind wing connected to the base of the discoidal cell by another nervure; membrane at base well defined blackish-brown; supplementary nervure, Rspl and Mspl present far away from IRiii and MA respectively; Riii forked near the inner end



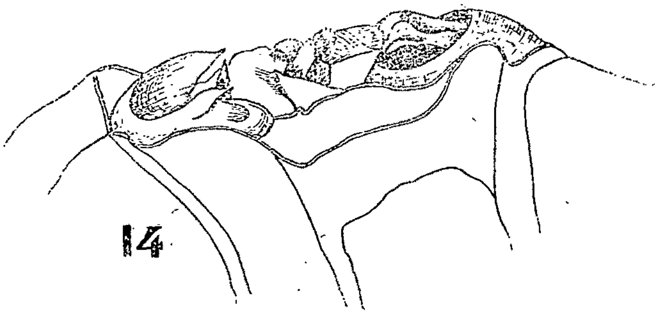
Anaciaeschna kashmirense, sp. nov. Male : FIG. 12. Base of Fore wing, enlarged.

of pterostigma, base of the hind wing notched, tornus angulated, pterostigma dark brown, covering 3 cells in the hind wing and 2 cells in fore wing; cubital nervure 4 in fore and hind wings; 4 rows of cells between branches of Ri and Riii. *Abdomen* long, cylindrical, warm reddish-brown, marked with pale blue and brown, segment 1 with a large brown and pale blue spot on each side; segment 2 with the sides shiny pale blue. Anal appendages dark reddish-brown. *Genitalia* as in figure 14.



13

Anaciaeschna kashmirense, sp. nov. Male : FIG. 13. Base of Hind wing, enlarged.



14

Anaciaeschna kashmirense, sp. nov. Male : FIG. 14. Genitalia, lateral view.

Female.—Hind wing 41 mm. Abdomen 42 mm. Differs from the male in colouring and marking. *Head* with the labium and labrum brown, the latter with anterior border black, mandibles black, frons and clypeus brown. *Pterothorax* yellow along the mesopleural suture, metasternum with broad yellow band. *Wing* deeply tinted with amber-yellow; pterostigma yellowish-brown, occupying four cells in fore wing and 3 cells in hind wing; tornus round. *Abdomen* brown, very much tumid and gradually tapering to end, without pale bluish marking, except the sutures, which are black; anal appendages brown and short.

Holotype male, *allotype* female. Dal Lake : Srinagar, Kashmir, Coll. M. S. Mani, 26-x-1953.

This species is readily separated from *A. jaspidea* Burm.[1] by its yellowish-brown labium, light brown labrum, which is bordered black in front; darker occiput; thorax not being reddish-brown, in the absence of greenish-yellow band on thorax in male, pterostigma in female 4 celled in fore and 3 celled in hind wing; in male 2 celled in fore and 3 celled in hind wing; anal loop with 7 cells, 4 cubitals in both wings, colour of abdomen and in the male genitalia.

Superfamily Libelluloidea

Famliy Libellulidae

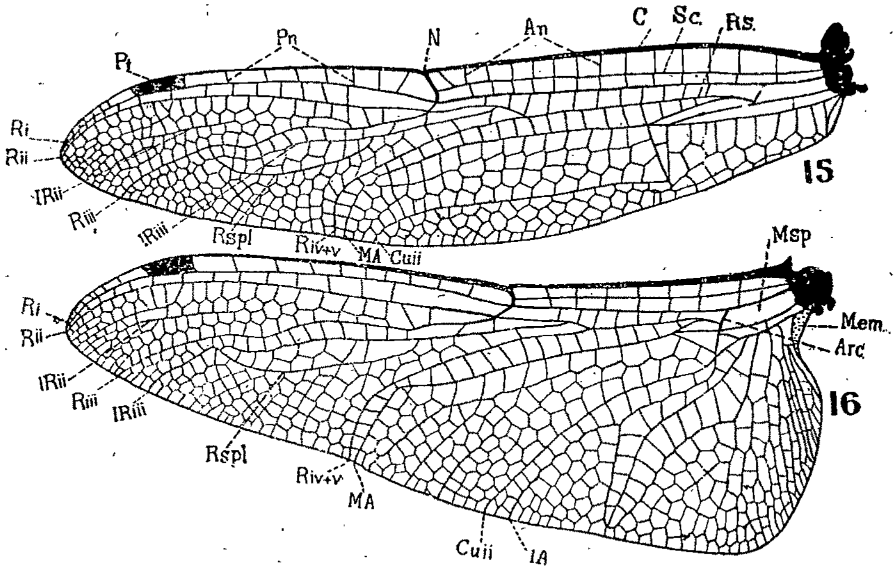
Orthetrum mathewi, sp. nov.

Female.—Abdomen 32 mm. Hindwing 41 mm. *Head* with eyes globular; labium yellow; labrum brown, with the anterior border black; clypeus dirty yellow; post-clypeus centrally yellow, laterally lighter; frons in front pale ochraceous but brown above; vesicle yellow anteriorly, brown backward, with a suture in the middle; occiput pale ochraceous. *Prothorax* light brown, with posterior lobe fringed with setae. *Pterothorax* clothed with setae, pale grey, mid-dorsal carinal suture marked black; antehumeral region brown; humeral suture above and below marked black, but without marked colour in the middle, mesepimeron pale grey; anterolateral suture above white and black below; posterolateral suture black; metepimeron pale grey. *Legs* black, with femora

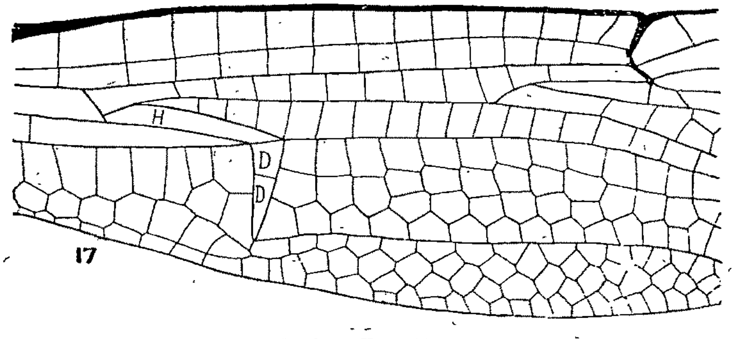
---

[1] Fraser, F. C. 1936. Fauna Brit. India, Odonata, **3** : 152.

yellowish-brown in front. *Wings* (figs. 15-16) hyaline, costal border and antenodal nervures yellow; pterostigma yellowish-brown, covering about one and a half cells; hind wing with a yellow margin at anal area; base of wing broad as in figure; antenodal index $\frac{14-13}{13-12}$ $\frac{9-7}{6-7}$, $\frac{7-7}{7-7}$ $\frac{9-10}{7-8}$, discoidal cell entire in hind wing as in fig. 18, but traversed in fore wing as in fig. 17; arculus between the first and second antenodal nervures; sector of arculus with a long fusion in both the wings; discoidal field with 3 rows of cells, widely dilated at wing border; 2 rows of cells between lRiii and Rspl; Cuii arising from the posterior angle of discoidal cell; only one cubital nervure in both the wings; membrane grey. *Abdomen* brown, tumid basally, first 3 segments

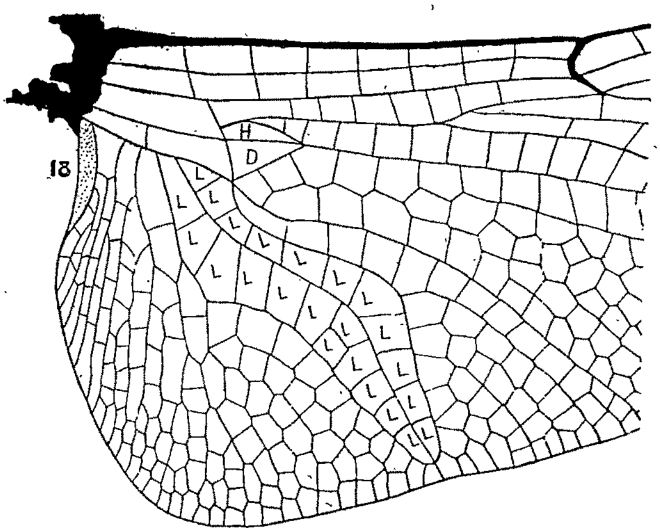


Orthetrum mathewi, sp. nov. Male : Fig. 15. Fore wing. Fig. 16. Hind wing.



Orthetrum mathewi, sp. nov. Male : Fig. 17. Base of Fore wing, enlarged.

livid, all sutures black; black stripe on either side of dorsum; anal appendages long, straight, black, acutely pointed apically.



Orthetrum mathewi, sp. nov. Male : FIG. 18. Base of Hind wing, enlarged.

Holotype female. Chakrata Range, 8000 ft. River Jamuna ravines. Coll. Koshy Mathew, 22-x-1953.

This species runs very close to *O. cancellatum cancellatum* (Linn.)[1], but differs in its relatively long and broad wings, pale grey pterothorax; brown abdomen; anal appendages black, much longer than in *O. cancellatum* or *O. japonicum internum* (MacLac.),[2] another related species, the appendages also being acute apically; membrane grey and in the different nodal index.

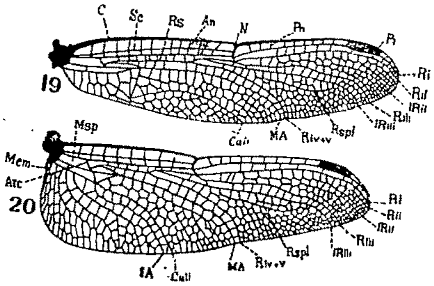
Orthetrum garhwalicum, sp. nov.

Male.—Abdomen 25 mm. Hind wing 29 mm. *Head* with the labium, labrum, face and frons yellow; veiscle and occiput brown; behind the head brown, spotted ochraceous-black. *Prothorax* black; anterior and posterior lobes with yellow marking. *Pterothorax* with setae, brown; antehumeral stripe dark brown; all sutures marked black, except the anterolateral; mesepimeron brown, but marked pale yellow anteriorly; metepimeron brown, lighter anteriorly. *Legs* black; femora yellowish-brown, with row of small spines, terminally the spines are somewhat larger.

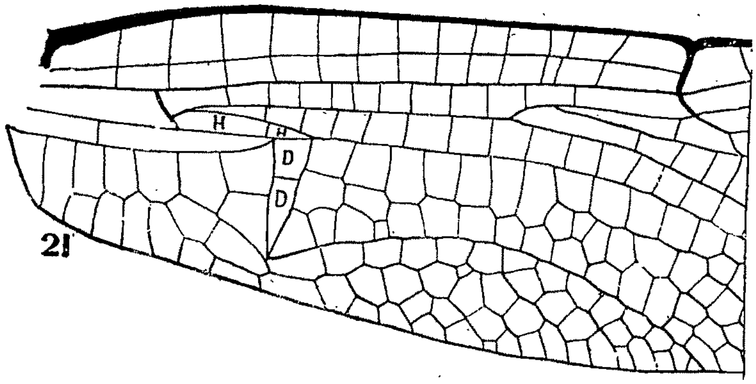
---

[1] FRASER, F. C. 1936. Fauna Brit. India, Odonata, 3 : 802. [2] *Ibidem*, 304.

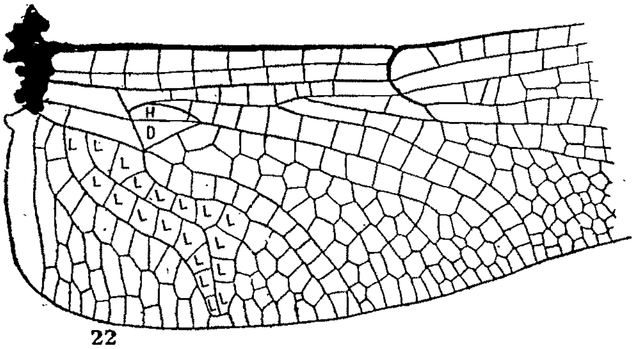
Wings (fig. 19-20) with costal border and antenodal nervures yellow; pterostigma largely yellow, but slightly darkened in front and somewhat apically, covering about two and a half cells in hind wing; one to two rows of cells between 1Riii and Rspl; arculus between the first and second antenodal nervures; Cuii arising from the posterior angle of discoidal cell in hind wing; discoidal cell in hind wing entire as in fig. 22; but in fore wing traversed (fig. 21); *abdomen* brown, tumid basally, tapering from there to anal end, strongly carinate from segment 4, triquetral



Orthetrum garhwalicum, sp. nov. Male : Fig. 19. Fore wing. Fig. 20. Hind wing.



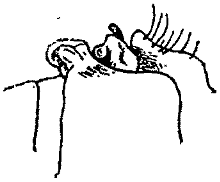
Orthetrum garhwalicum, sp. nov. Male : Fig. 21. Base of Fore wing, enlarged.



22

Orthetrum garhwalicum, sp. nov. Male : Fig. 22. Base of Hind wing, enlarged.

in cross-section, all sutures black and subdorsal black stripes; anal appendages black, with apices brown. Genitalia as in fig. 23.



23

Orthetrum garhwalicum, sp. nov. Male : FIG. 23. Genitalia, lateral view.

Female.—As in male except the following : face and frons yellow; vesicle yellowish-brown; occiput brown, with boundary somewhat yellow; pterothorax with antehumeral stripe pale yellow; lower portion of metepimeron pale yellow anteriorly; abdomen light brown, wth a narrow black stripe on middorsum from segment 2 to 9; legs pale yellow, with the posterior femoral region black; anal appendages short, acute.

Holotype male, *allotype* female : *paratypes* one male and female : Chakrata Range, 8000 ft. River Jamuna ravines; Coll. Sharda Singh & Koshy Mathew, 22-ix-1953.

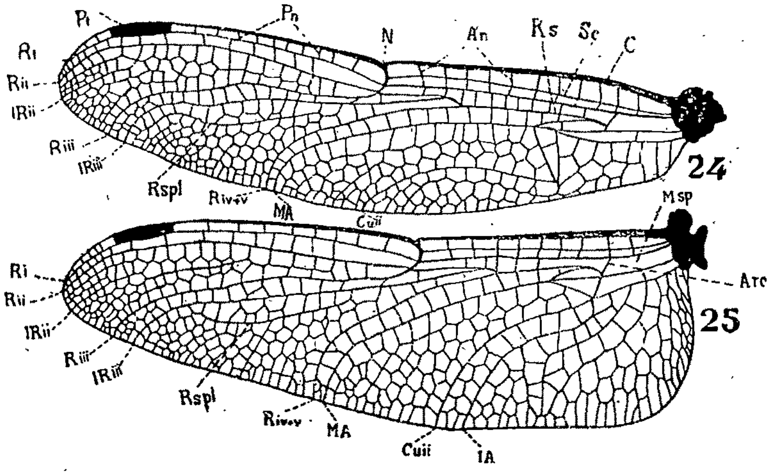
This species is distinguished from *O. cancellatum* (*loc. cit.*) by its yellow labrum, without any median black spot; yellow face and frons, without base narrowly black; brown occiput and pterothorax; very dark brown antehumeral stripe; pterostigma largely yellow but slightly darkened in front and apically; abdomen 3-7 not pulverulent; anal appendages brown apically and by the different genitalia.

Orthetrum glaucum (Brauer)

1865. *Libellula glauca*, BRAUER, *Verh. zool.-bot. Ges. Wien*, **15** : 1012.
1890. *Orthetrum glaucum*, KIRBY, *Cat. Odonata*, 39.
1918. *Orthetrum glaucum*, FRASER, *J. Bombay nat. Hist. Soc.*, **26** : 156, 166-167.
1936. *Orthetrum glaucum*, FRASER, *Fauna Brit. India*, Odonata, **3** : 307.

We refer to this species two males labelled "Chakrata Range, 8000 ft. R. Jamuna ravines (Garhwal); coll. Koshy Mathew & Sharda Singh, 21-22.ix. 1953.

The specimens before us differ from the published descriptions of the species in the following respects : Labium, labrum and prothorax brown, the last without any yellow marking; legs entirely black; the dark amber yellow spot on base of hind wing only restricted to the anal area and not extending to the cubital nervure; one or two rows of cells between IRiii and Rspl (figs. 24-25). The nodal index and the markings on abdomen also differ.

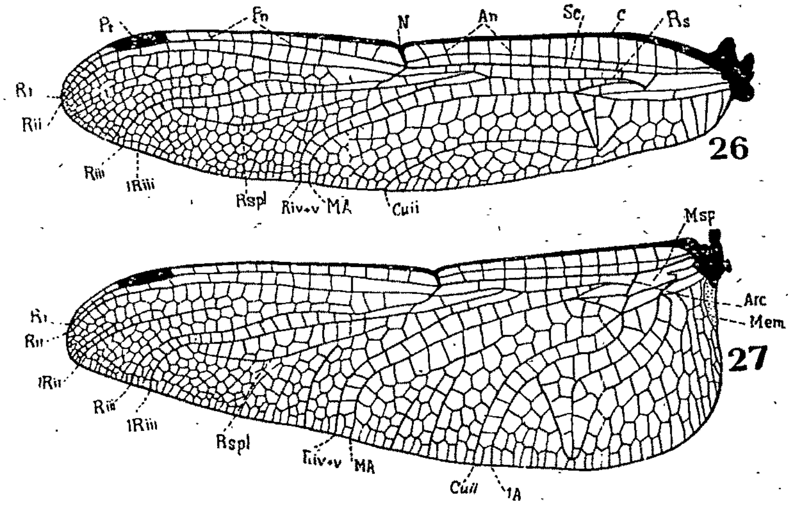


Orthetrum glaucum (Brauer) Male : FIG. 24. Fore wing. FIG. 25. Hind wing.

Orthetrum triangulare triangulare (Selys)

1878. *Libellula triangularis*, SELYS, *Mitt. Mus. Dresden*, p. 314.
1918. *Orthetrum triangulare*, FRASER, *J. Bombay nat. Hist. Soc.*, **26** : 156, 164-166.
1936. *Orthetrum triangulare triangulare*, FRASER, *Fauna Brit. India*, Odonata, **3** : 305.

We have before us 6 males labelled "Chakrata Ranges, 8000 ft. R. Jamuna ravines, Garhwal; coll. R. S. Mathur & Sharda Singh, 21-22.ix.1953". We have no doubt about the identification of this species, although the specimens before us show certain minute differences from the description of the species. Hind wings with a triangular blackish-brown spot at base, not extending to the third antenodal nervure, arculus and beyond the cubital nervure; a vestige of same in fore wing not extending upto the first antenodal nervure; discoidal cell in fore wing 2-celled; only 2 cells in subtrigone of fore wing (figs. 26-27).

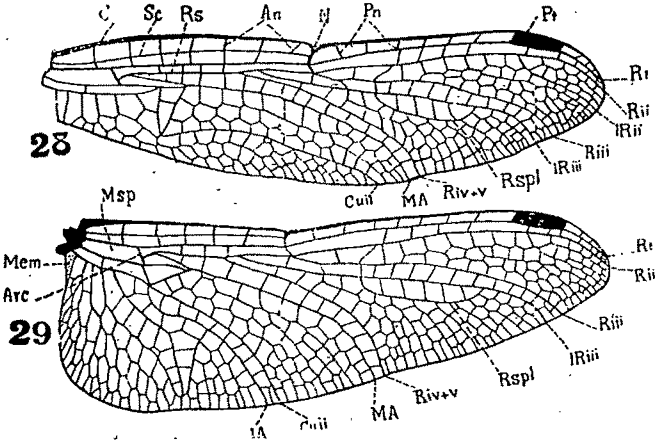


Orthetrum triangulare triangulare (Selys) Male : FIG. 26. Fore wing. FIG. 27. Hind wing.

Sympetrum commixtum (Selys)

1884. *Diplax commixtum*, SELYS, *Ann. Soc. ent. Belg.*, **28** : 38.
1886. *Sympetrum subpruinosum*, KIRBY, *Proc. zool. Soc. London*, 326, pl. iii, fig. 7.
1919. *Sympetrum commixtum*, FRASER, *J. Bombay nat. Hist. Soc.*, **26** : 495, 498.
1936. *Sympetrum commixtum*, FRASER, *Fauna Brit. India*, Odonata, **3** : 372, fig. 107a.

We have before us one male (figs. 28-29) labelled "Gulmarg, Kashmir, 8700 ft; coll. Santokh Singh, 26-27.x.1953." The species has previously been recorded from North-west India (Prepartition), Abottabad, Yusimarg (Kashmir) and other parts of North India.



Sympetrum commixtum (Selys) Male : FIG. 28. Fore wing. FIG. 29. Hind wing.

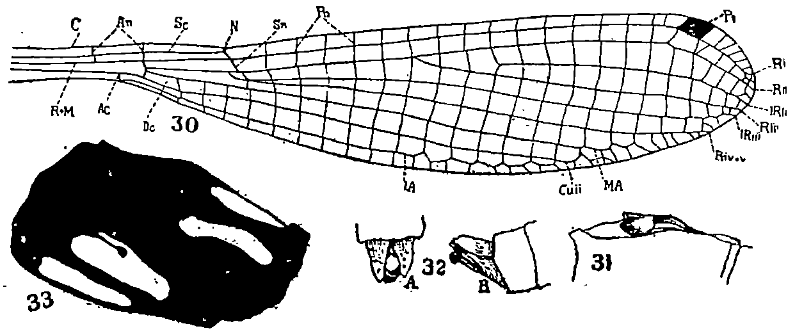
Suborder ZYGOPTERA

Family Coenagriidae

Subfamily Platycneminae

Coeliccia kumaonensis, sp. nov.

Male.—Abdomen 50 mm. Hind wing 29 mm. *Head* black, except for the pale yellow labium. *Pro and pterothorax* (fig. 33) black on dorsum; antehumeral stripe whitish-yellow; mid-dorsal carina black; humeral suture black; a whitish-yellow spot between anterolateral suture and posterolateral suture; metepimeron with whitish-yellow spot; *Leg* black, with femora pale yellow basally. *Wings* (fig. 30) hyaline; pterostigma black, covering one cell; Riv+v arising a little proximal to subnode; 1Riii a little distal; postnodal nervures 16 in both the wings. *Abdomen* black, cylindrical, moderately robust and very long; segments 8 and 9 swollen; anal appendages (fig. 32a-b) creamy-white; superior appendages triangular when viewed from above; broad basally, acute apically, with a single spine; inferior appendages forcipitate; genitalia as in fig. 31.



Coeliccia kumaonensis, sp. nov. Male : FIG. 30. Hind wing. FIG. 31. Genitalia, latera view. FIG. 32. Anal appendages, A. Dorsal view; B. Lateral view. FIG. 33. Pterothorax.

Holotype male Jeolikote (Nainital District), 5500 ft. Kuamon Himalayas; coll. H. N. Baijal & K. J. Padmavathy, 18-ix-1952.

This species is distinguished from the closely related *C. bimaculata* (Laidl.) and *C. fraseri* (Laidl.)[1] by the bases of mandibles and prothorax not being pale blue or yellow; sides of pterothorax not being pale blue; legs not creamy-white; black abdomen, not yellowish laterally; superior anal appendages not deeply excavate within. The genitalia are also quite different.

---

[1] FRASER, F. C. 1933. Fauna Brit. India, Odonata, **1** : 154-169.

CONTRIBUTIONS TO OUR KNOWLEDGE OF FIG INSECTS (CHALCIDOIDEA: PARASITIC HYMENOPTERA) FROM INDIA*

VI.—On six Species of Agaoninae.†

By K. J. Joseph, *Senior Research Scholar, Govt. of India Ministry of Education, School of Entomology, St. John's College, Agra.*

The type specimens of the new species described in this paper are in the collections of the School of Entomology for the time being.

I thank Prof. M. S. Mani for facilities for work, for constant encouragement and for guidance.

Family Agaontidae

Subfamily Agaoninae

Blastophaga vaidi, sp. nov.

Female.—Dark smoky-brown; legs and antennae pale smoky-brown; eyes coralline; alar membrane hyaline; nervures pale brown, pubescence pale brownish-black.

Head (Fig. I, 1) distinctly wider between the external margins of the eyes than long; lateral margin forwards of eye about one-third the longitudinal diameter of the eye; posterior angles behind the eyes not rounded but obtuse; posterior margin weakly concave in the middle as in figure; the sublateral chitinised area of the dorsum of head with numerous small setae; the posterior median area of the frons triangular, feebly chitinised and bears the three ocelli as in figure. Antenna (Fig. I, 2) with eleven segments; scape large and massive, subcompressed, length a little less than one and a half times its maximum width, with a distinct anguloso-rounded projection on its inner margin; second segment a little over one and a half times as long as its maximum thickness, with a number

---

*Contribution No. 46 from the School of Entomology, published with the permission of the Professor of Zoology & Entomology.

†Part V of this series was published in the *Agra Univ. J. Res.*, (Sci.) **3** (1) : 43-94 (1954).

of short thick setae of which those on the dorsal side are directed backwards; third segment quite characteristic of the group, divided into three parts of which the basal portion is somewhat annular with a short thick spine as in figure; fourth shortest of all, subcylindrical, a little longer than thick; fifth, sixth, seventh, eighth and ninth segments narrow at base, thickening distalwards; sixth a little longer and thicker than fifth; seventh a little shorter than sixth but a trifle thicker than it; eighth hardly as long as the sixth, a little thicker than the seventh; ninth and tenth segments of equal dimensions; segments five to ten with setae and long sensoria as in figure; eleventh segment short, subconical, provided with a few long setae, a few long sensillae and short and oval sensory rods; the last three segments form a club of length equal to two and two-thirds its maximum thickness. Mandible (Fig. I, 3) large and robust, a little wider than long, bidentate, with setae as in figure; appendage twice as long as wide, with five ventral transverse laminar elevations. Maxilla (Fig. I, 4, mx.) consists of two

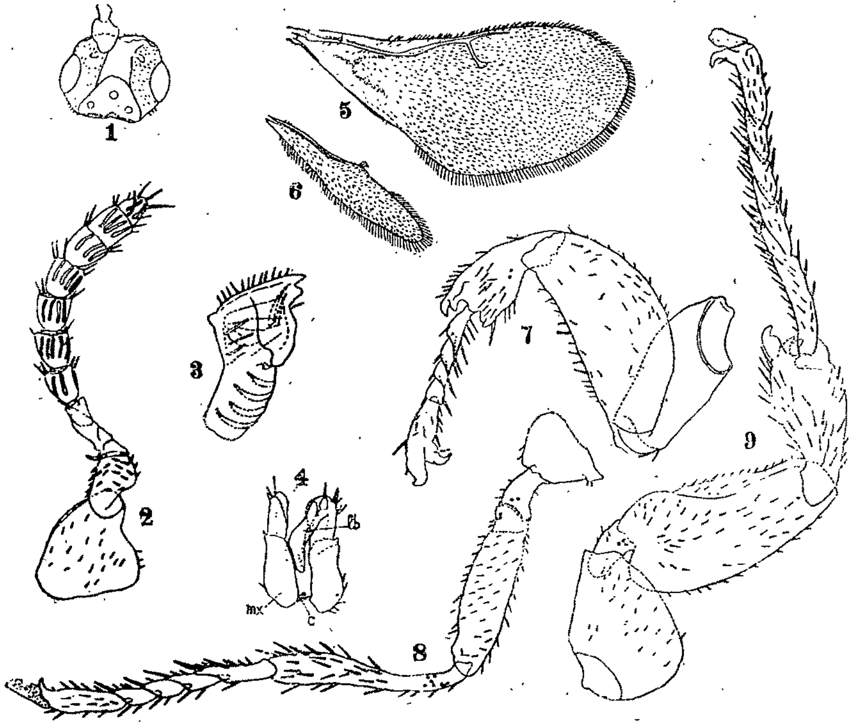


Fig. I.—*Blastophaga vaidi*, sp. nov. Female: 1, head; 2, antenna; 3, mandible; 4, maxillae and labium; 5, fore wing; 6, hind wing; 7, fore leg; 8, mid leg; 9, hind leg; mx., maxilla; lb., labium; c, cardines.

elongated, thin and flattened pieces, of which the basal piece (stipes) is well chitinised; while the distal piece is chitinised only along its external margin. The distal extremity of the latter is rounded or projecting as in figure, with a fringe of minute setae and four long setae. The external distal margin of the basal piece is prolonged into a short digitiform process which probably represents the rudimentary maxillary palpus. The maxilla is articulated at its base to the ventral side of the cranium by means of two short sclerotised rods, the cardines (Fig. I, 4, c). Labium (Fig. I, 4, lb) is represented by a strongly compressed, flat piece lying between the distal two-thirds of the maxillae. It is strongly chitinised along its ventral concave margin, and divided into two pieces, of which the proximal one is chitinised and the distal one submembranous. The latter part terminates in a projecting margin bearing a fringe of minute setae. The ventral chitinised distal margin of the labium is differentiated into a dilated process with a subconical chitinised piece bearing a thick acuminate seta apically.

Thorax: Pronotum furnished with a few small setae. Mesonotum with the scapula about one and two-thirds as long as wide, glabrous; scutum wider than long, glabrous; scutellum a little wider than long, with about eleven short satae in its median part; length of parascutellum twice its width; axilla a little wider than long, with two short satae. Length of thorax and propodeum one and one-sixth the width of the mesonotum. Fore wing (Fig. I, 5): Length a little over two and one-fourth its breadth; submarginal vein four times the marginal, with four small, rounded sensillae in its distal thickened portion; marginal vein a little longer than the postmarginal; postmarginal equal to the stigmal; stigmal vein distinctly dilated at its apex, with two small, rounded sensillae; length of costal cell about eleven times its width; pubescence short; marginal fringe short in the posterior margin of the wing. Hind wing (Fig. I, 6) : Length a little less than five times its breadth, with three frenal hooks; pubescence short; marginal fringe long. Fore leg (Fig. I, 7): Coxa a little less than two and a half times as long as wide; trochanter indistinct; femur large, two and one-third as long as wide, its ventral margin substraight, setae as in figure; tibia a little over twice as long as wide, with a few long setae of which one on the ventral distal margin is longer, sensillae and three dentiform processes as in figure. Length of tarsi a little over one and a half times the tibia; metatarsus equal to the two following segments combined, and equal to the fifth segment. Mid leg (Fig. I, 8) : Coxa about one and one-third as wide as long; trochanter one and two-thirds as long as its width, with sensillae and setae as in figure; femur with a prominent feebly chitinised subtransparent area proximally, length about three and a half times its maximum width, with numerous long setae; tibia about six and a half times as long as wide, proximal part narrow with a few sensillae, distal half distinctly wider with many long setae. Tarsi a little longer than the tibia; metatarsus a little shorter than the combined length of the two following segments; fifth equal to the metatarsus. Hind leg (Fig. I, 9) : Coxa about one and a half times as long as wide, attenuated distalwards, compressed, with setae as in figure; trochanter longer than one and a half times its maximum width, with setae and sensillae as in figure; femur large, compressed, length about twice its maximum width, narrowed distalwards, with setae as in figure; tibia stout, narrowed proximally, length about two and a half times its maximum width, with a complex tridentate process on its outer face and a long, compressed, recurved odontoid spine on its inner face, with numerous long setae as in figure. Tarsi long, two and one-fourth as long as the tibia; metatarsus longer than the two following segments combined; fifth segment two-thirds the combined length of the second and third segments. Propodeum a little wider than four times its maximum length.

Abdomen: A little longer than wide ; eighth urotergite with a pair of spiracles with small, rounded peritremes : ninth with a pair of short subcylindrical cercoides, each bearing five long setae : ovipositor-valve about one-third the length of the abdomen.

Measurements. Length of body : 1. 84 mm. ; length of head: 0. 4 mm.; width of head: 0. 47 mm.; length of thorax and propodeum: 0. 77 mm.; width of mesonotum: 0. 66 mm. : length of fore wing: 1. 5 mm.; width of fore wing : 0. 68 mm. ; length of hind wing: 0. 9 mm. ; width of hind wing: 0. 18 mm.; length of abdomen: 0. 73 mm. ; width of abdomen: 0. 68 mm. ; length of ovipositor-valve: 0. 24 mm.

Male.—Head, thorax and abdomen upto the sixth segment rusty yellow-brown; legs brownish-yellow except for the fore tibiae and parts of the hind tibiae ; antenna and the tubular part of the abdomen melleous ; mandibles rusty red-brown ; eyes black.

Head (Fig. II, 10) a little wider than long, somewhat rounded in outline; lateral margins converging forwards; posterior margin rounded; frons with an anterior inflection developing a distinct concavity; dorsum of head in its anterior two-thirds with numerous short, stout spiny processes as in figure; eyes lateral, well behind the anterior margin. Antenna (Fig. II, 11) short, stout and consists of a radicle and four free segments ; radicle three-fifths as long as the scape, narrow basally; scape stout, length about one and one-third width, provided with a few short setae on its outer face and a few sensillae on its inner face as in figure; second segment about one and one-third as long as thick, two thirds as long as the scape, thicker distalwards; third annular, slightly thicker than the preced-

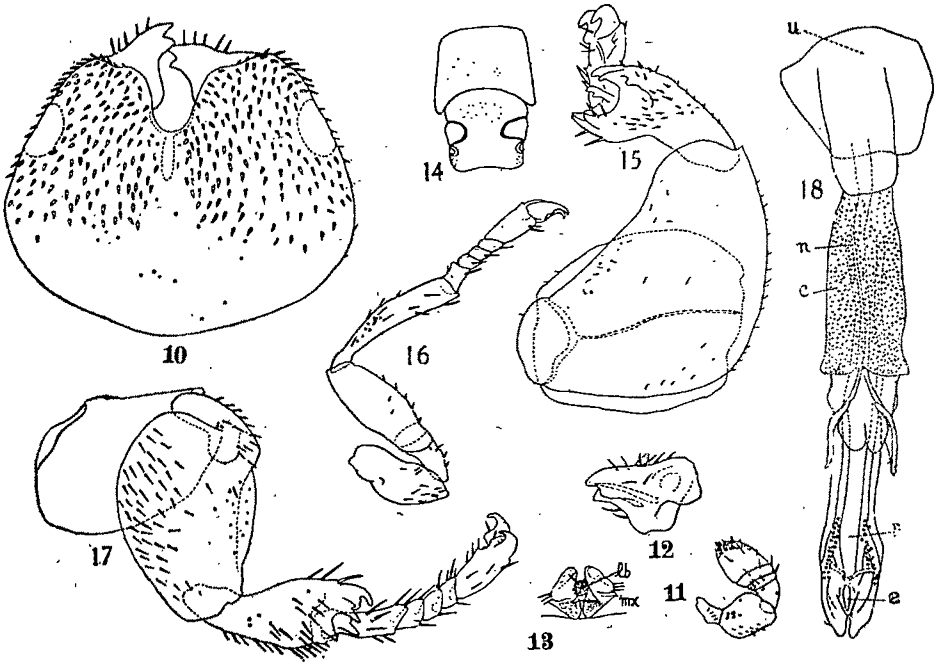


Fig. II.—*Blastophaga vaidii*, sp. nov. Male : 10, head; 11, antenna; 12, mandible; 13, maxillae and labium; 14, thorax and propodeum; 15 fore leg; 16, mid leg; 17, hind leg; 18, ninth urite, intersegmental membranous collar and genital armature; u, ninth urite; c, intersegmental membranous collar; n, proximal bascilliform process of the penis; p, penis; e, genital opening; mx; maxilla; lb., labium.

ing, setae as in figure; fourth subovoid, divided by two transverse lines into three parts of which the proximal part is fairly distinct, irregularly annular, thicker and longer than the third segment and provided ventrally with setae as in figure. The median portion of the fourth segment is thrice as long as the proximal portion, is thicker than it and constitutes the body of the segment, its lateral margins weakly converging forwards; on its inner face it bears three long setae as in figure. The distal portion of the fourth segment is subhemispherical and provided with many sensoria of which some are large and ovoid, others rod-shaped. Mandible (Fig. II, 12) small, stout, distinctly wider than its maximum length, bidentate; teeth and setae as in figure. Maxilla (Fig. II, 13, mx.) consists of a small piece divided incompletely into two parts : a proximal wider piece and a distal narrower but longer piece. The proximal piece is almost wholly chitinised. Only a small posterior outer area of the distal piece is chitinised and bears in this region three long setae and in its distal half a series of irregular fringes. Labium (Fig. II, 13, lb) is a wholly chitinised subtriangular piece provided with a subspheroidal knob-like structure which bears a stout rigid seta anteriorly.

Thorax (Fig. II, 14): Pronotum large, subquadrangular, distinctly wider than long; dorsum convex; anterior margin feebly convex; lateral margins faintly converging forwards. Length of rest of thorax and propodeum equal to the width of the mesonotal region which is not demarcated from the propodeal region; metanotum represented by a pair of latero-dorsal areas; propodeal tracheal spiracles with elongate and curved peritremes. Fore leg (Fig. II, 15): Coxa a little longer than wide, somewhat narrower basally, with a distinct longitudinal endoscleritic carina which reaches its distal end; trochanter indistinct; femur distinctly compressed, large, about one and a half times as long as its maximum width, with a convex dorsal margin and a weakly concave ventral margin. Tibia a little longer than half the femur, subcylindrical proximally, enlarged and stout distally; its outer face with a distal concavity bounded dorsally by a bidentate margin and ventrally by a tridentate margin, between which, in the concavity is situated a long, stout, bifid spine. The tibia is furnished with numerous spines, some of which are long and stout, others short. Tarsi two-segmented, longer than half the tibia; metatarsus hardly a little less than half the tarsal length; with a few long, stout setae near its ventral margin; second segment large, subcompressed, longer than the metatarsus, with a few setae. Mid leg (Fig. II, 16): Coxa compressed, length a little over twice width, narrowed distally, with setae and sensillae as in figure; trochanter subcompressed, length one and a half times its maximum width, with a few-setae and sensillae; femur subcompressed, length two and one-third its width, dorsal and ventral margins convex, with a few setae; tibia a little recurved, length a little less than six times its maximum width, one and one-third as long as the femur, narrow proximally where it is furnished with a few rounded sensillae, setae as in figure. Tarsi three-fourths the tibia; metatarsus a little shorter than the two following segments combined. Hind leg (Fig. II, 17): Coxa about one and a half times as long as wide; trochanter short. Femur large, length about one and one-third width; dorsal margin rounded, ventral margin as in figure. Length of tibia four-fifths the femur; its outer face at its distal extremity with a complex tridentate process formed of stout teeth of which the ventral one shows a short secondary process; the inner face is provided distally near its ventral margin, with a large, laminar, claw-like, recurved spine; on its outer face the tibia is furnished with a few sensillae and setae as in figure. Tarsi about one and one-fourth the tibia; metatarsus subcylindrical, distinctly longer than the two following segments combined; fifth segment shorter than the metatarsus and equal to the combined length of the second and third segments.

Abdomen: Length twice its maximum width; segments seven, eight and nine tubular. Genital armature (Fig. II, 18) short, chitinised and provided with two ventral, laminar, sublateral, submembranous processes which are rounded at their apices; penis depressed, long, slightly narrowed and bilobed at apex, with two long bascilliform processes and with numerous sensillae irregularly disposed sublaterally a little to the front of the genital opening; genital opening elongated, subdistal.

Measurements. Length of body: 1.84 mm.; length of head: 0.38 mm.; width of head: 0.44 mm.; length of pronotum: 0.29

mm.; width of pronotum: 0.46mm.; length of rest of thorax and propodeum: 0.38mm.; width of mesonotum: 0.38mm.; length of abdomen: 0.97mm.; width of abdomen: 0.46 mm.

This species is related to *Blastophaga psenes* Linn.

Holotype female dissected on slides No. 15/5-1, 15/5-2 and 15/5-3; *allotype* male dissected on slides Nos. 15/6-1, 15/6-2 and 15/6-3. *Paratypes* 14 females and several males in spirit.

Collected by K. J. Joseph from the figs of *Ficus palmata* Forsk., from the Forest Research Institute Estate, New Forest, Dehra Dun, 23-vi-1953.

B. psenes Linn.

1758. *Blastóphaga psenes*, LINNAEUS, *System. Natur.* Edit. (X) **1** : 554, n. 13.
1829. *Blastophaga grossorum*, GRAVENHORST, *Ubers. Arbeit. Schles. Ges. f. vaterl. Cultur. i. J.* p. 27
1837, 1840. *Blastophaga sycomori*, WESTWOOD, *Trans. ent. Soc. London*, **2** : 220.
1822. *Blastophaga psenes*, WESTWOOD, *Ibid.*, 55-58.
1882. *Blastophaga grossorum*, MAYR, *Mittheil. Zool. Stat. z. Neapel*, **3** : 551-590.
1885. *Blastophaga grossorum*, MAYR, *Verh. zool. bot. Ges. Wien*, **35** : 177-179.
1920. *Blastophaga psenes*, GRANDI, *Boll. Lab. Zool. Portici*, **14** : 63-204.
1929. *Blastophaga psenes*, GRANDI, *Boll. Lab. Ent. Bologna*, **2** : 1-147.

I refer to this species several females and males collected by Dr. S. N. Rao from the figs of *Ficus carica* Linn. and labelled "Bagh Muzaffarkhan, Agra, 19-iv-1949."

This Palaearctic species is associated with the well-known Smyrna Fig (*Ficus carica* Linn.) in Asia Minor. The area of its distribution extends from Eastern Persia and Afghanistan across the countries of the Mediterranean Region to the Canaries Islands and has been introduced into California and some other parts of the world. It is also known from other species of *Ficus*, viz., *F. serrata* Forsk., *F. pseudocarica* Miq., and *F. persica* Boiss.

The species is here being recorded for the first time from India, and indeed, from the Oriental Region. The gradual extension of cultivation of the host plant *F. carica* Linn. to N. W. India probably accounts for the occurrence of the Palaearctic insect (*B. psenes* Linn.) in India.

Ceratosolen emarginatus Mayr

1906. *Ceratosolen emarginatus*, MAYR, *Wien. ent. Zeitung*, **25** : 153-154.
1927. *Ceratosolen effractarius*, GRANDI, *Boll. Lab. Zool. Portici*, **20** : 169-174.
1928. *Ceratosolen emarginatus*, GRANDI, *Boll. Lab. Ent. Bologna*, **1** : 189-190.

I refer to this species several females and males, on slides and in spirit, collected by K. M. Vaid and K. J. Joseph from the figs of *Ficus roxburghii* Wall. and labelled "On way to Robbers' Cave, Dehra Dun, 30-vi-1953." Mayr (loc. cit.) and Grandi (loc. cit.) studied the species from China and Indochina. I here record the species for the first time from India.

C. gravelyi Grandi

1916. *Ceratosolen gravelyi*, GRANDI, *Boll. Lab. Zool. Portici*, **11** : 201-207.

I refer to this species several males on slides and in spirit, collected by K. J. Joseph from the figs of *Ficus cunia* Hann. and labelled "Forest Research Institute Estate, New Forest, Dehra Dun, 25-vi-1953."

In several of the specimens studied by me, the mid and hind tarsal segments are variously fused along their dorsal margins (Fig. IV, 37 & 38) or show reduction in number (Fig. IV, 39 & 40) from their normal pentamerous condition (Fig. IV, 36 & 41).

Eupristina belgaumensis, sp. nov.

Female.—Head, thorax, abdomen and ovipositor-valves dark brownish; legs and ovipositor pale yellowish-brown; first three antennal segments yellowish with an admixture of reddish-brown, rest of antenna smoky-brown; wings hyaline.

Head (Fig. III, 19): Longer than wide between the external margins of the eyes; epistomal margin with a rounded sublateral lobe bearing a single long seta and a small median angular process with a pair of setae; lateral margin of head forwards of eye equal to the longitudinal diameter of the eye, substraight and weakly converging forwards; posterior margin of head behind the eyes rounded and weakly concave in the middle. Eyes small, little projecting; ocelli three, as in figure. Dorsum of head with numerous minute setae. Antenna (Fig. III, 20) : Length of scape less than twice its maximum width, shape and setae as in figure; second segment about one and a half times as long as thick, with numerous short, thick, backwardly directed spines on its outer face; third about one and a half times as long as thick, incompletely divided into two, setae as in figure; segments four to eleven narrow basally, thick distalwards; fourth segment a little longer than its maximum thickness; fifth longer than thick, larger than fourth; sixth shorter than fifth, as long as thick; fifth and sixth segments with sensoria which project hardly a little beyond the distal margins of these segments and with one or two digitiform sensory rods; seventh distinctly larger than any of the flagellar segments of the antenna, about one and one-third as long as thick, with two transverse rows of sensoria of which the distal row of sensoria project well beyond the distal margin of the segment; eighth a little thicker distally than long; ninth larger than eighth, as long as its maximum thickness; tenth a little longer than eighth but distinctly less thick, longer than thick; eighth, ninth and tenth segments of similar shape and with a row of long sensoria which

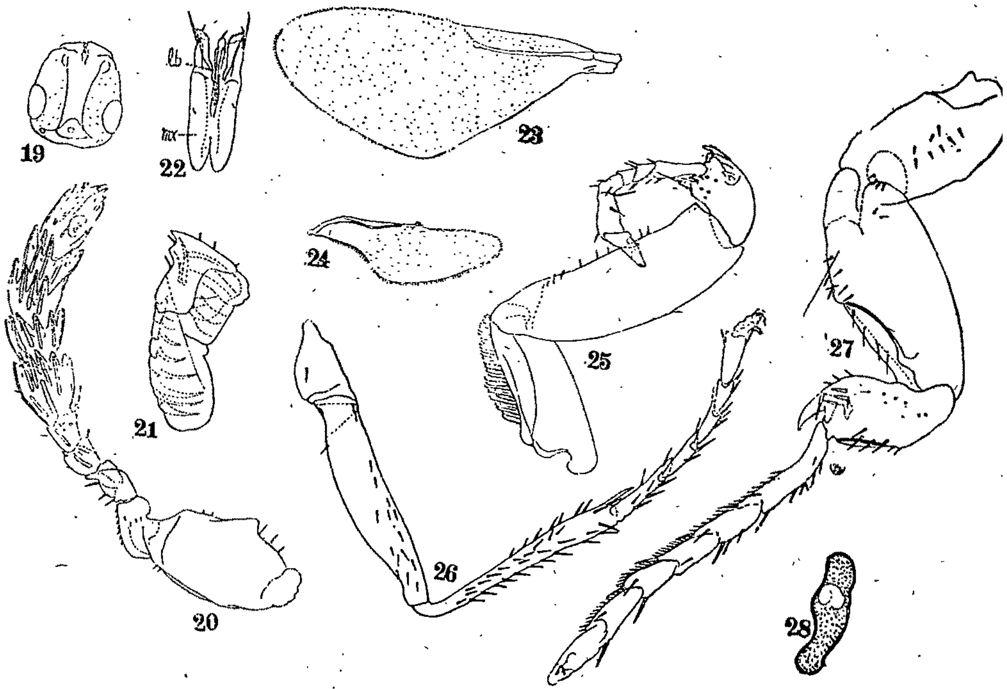


Fig. III.—*Eupristina belgaumensis*, sp. nov. Female : 19, head; 20, antenna; 21, mandible; 22, maxillae and labium; 23, fore wing; 24, hind wing; 25, fore leg; 26, mid leg; 27, hind leg; 28, spiracular peritreme of the eighth urite; mx., maxilla; lb., labium.

project well beyond the distal margins of these segments; eleventh a little shorter than seventh, slightly less than one and a half times as long as thick, with long sensoria, sensory rods, and a large oval facet bearing two large sensillae. Mandible (Fig. III, 21) a little wider than long, bidentate, with about six elevated ridges ventrally; appendage about thrice as long as wide, a little over one and a half times as long as the body of the mandible, ventrally with eight transverse ridges of which the basal two are little developed, the next two more pronounced, the remaining four large and well developed. Besides these transverse ridges there are present four flat tooth-like processes on the internal margin of the appendage. Maxilla (Fig. III, 22, mx) long, depressed, narrow, pointedly rounded basally; its proximal part well chitinised and large. Its distal part is divided into an outer and an inner portions; this outer portion is a little narrowed towards apex and with two setae of which the one on the distal extremity is markedly shorter than the one which is latero-distal; the inner portion points outwards and bears a fringe of short setae. Labium (Fig. III, 22, lb) lies between the two maxillae, long and slender, with a basal portion having two distinct chitinised areas; its distal portion shows two parts—a dorsal chitinised claviform structure with an enlarged subglobose distal part bearing a single stout seta at its apex and a ventral laminar structure with a fringe of minute setae along its distal margin.

Thorax: Pronotum large, its anterior margin rounded, lateral margins converging forwards, postero-lateral margins diverging forwards, posterior margin concave; it is furnished with numerous minute setae borne on wart-like rounded fossets. Mesonotum with the scutum one and one-third as wide as long, with about nine fossets bearing minute setae on each of its postero-lateral regions; scapula a little longer than wide, with about eleven fossets sublaterally with minute setae; parapsidal furrows complete; scutellum wider than long, with five large fossets bearing minute setae on each of its postero-sublateral regions and six short setae in its postero-median region; parascutellum thrice as long as wide, without fossets or setae; axilla one and three-fourths as long as wide, with about nine fossets bearing minute setae. Length of thorax and propodeum equal to one and one-third the width of the mesonotum. Post-phragma well developed and projecting well beyond the posterior margin of the propodeum. Fore wing (Fig. III, 23): Length a little over twice its breadth ; submarginal vein reaches to about two-fifths the wing length, a little recurved and abruptly terminating in a dilatation and provided distally with three rounded sensillae in a triangle and with another subdistal sensilla bearing a seta; pubescence microscopic; marginal fringe very short. Hind wing (Fig. III, 24) : Length about thrice its maximum width, with three frenal hooks; marginal fringe short. Fore leg (Fig. III, 25) : Coxa about thrice as long as wide, its ventral margin with a conspicuous lamellate expansion bearing a fringe of long setae; trochanter not very distinct; femur two and three-fourths as long as wide, with a few setae along its ventral margin; tibia less than half the femur, twice as long as wide, with a five-dentate expansion on its outer face; setae and sensillae as in figure. Length of tarsi one and two-thirds that of the tibia; metatarsus longer than the two following segments combined; fifth segment shorter than the metatarsus. Mid leg (Fig. III, 26): Trochanter subtriangular, about one and a half times as long as wide, with a distal ring-like subdivision; length of femur four and a half times its width, with a subtransparent area basally; tibia longer than femur, with many long and stout setae and an apical spur as in figure. Tarsi a little shorter than the tibia; metatarsus shorter than the two following segments combined; fifth a little shorter than the second. Hind leg (Fig. III, 27): Coxa twice as long as wide, with setae as in figure; trochanter twice as long as wide; femur about twice as long as wide, its ventral margin on the inner face distinctly incavated and thickened; the ventral margin on its outer face bears a lamellate expansion. Tibia three-fifths the femur, twice as long as wide, with a number of sensillae basally, and with a large tridentate process distally on its outer face; its inner face with three odontoid spines and a distinct lamellate expansion along its dorsal margin; setae as in figure. Length of tarsi two and a half times the tibia; metatarsus a little longer than the two following segments combined, fifth segment equal to the third.

Abdomen: Longer than wide; eighth urite with a pair of spiracles with large, elongate peritremes (Fig. III, 28); ninth small, with a pair of short, subcylindrical cercoides bearing four long setae each; length of ovipositor and of its valves equal to one and one-third that of the abdomen.

Measurements. Length of body: 1.7mm.; length of head: 0.46 mm.; width of head: 0.42 mm.; length of thorax and propodeum: 0.66 mm.; width of mesonotum: 0.59 mm.; length of fore wing: 1.47 mm.; width of fore wing: 0.68 mm.; length of hind wing: 0.86 mm.; width of hind wing: 0.29 mm.; length of abdomen 0.68 mm.; width of abdomen: 0.51 mm.; length of ovipositor: 0.97 mm.

Male.—Rusty yellow-brown; mandibles reddish-brown; eyes black; antennae and abdomen brownish-yellow.

Head (Fig. IV, 29) a little wider than long, strongly dilated posteriorly and converging forwards; posterior margin of head trilobed; epistomal margin with two little projecting rounded

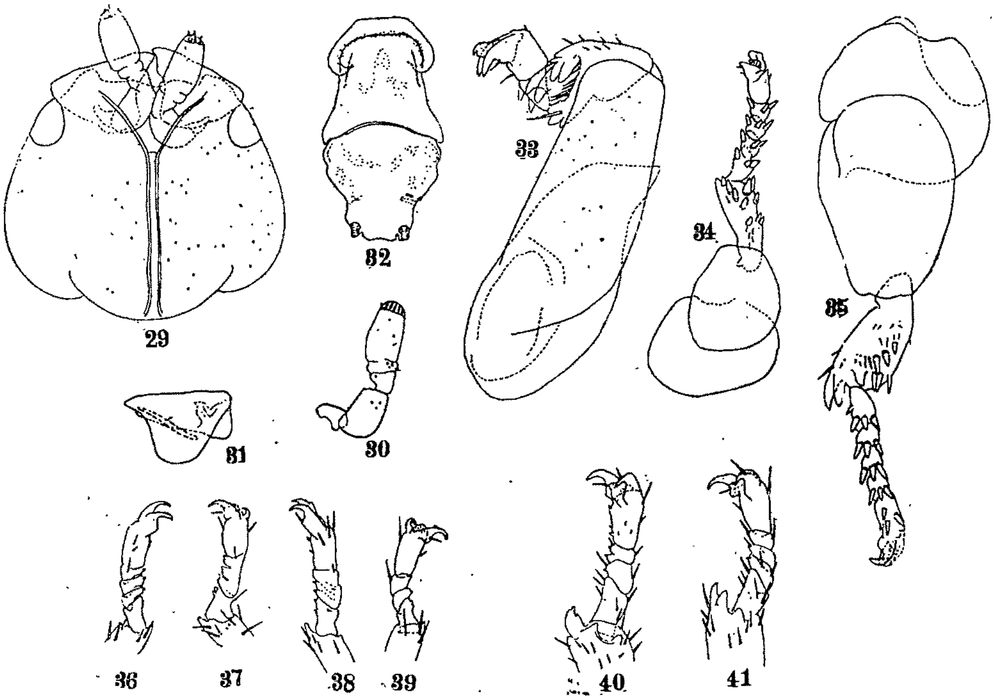


Fig. IV.—*Eupristina belgaumensis*, sp. nov. Male : 29, head; 30, antenna; 31, mandible; 32, thorax and propodeum; 33, fore leg; 34, mid leg; 35, hind leg.
Ceratosolen gravelyi, Grandi, male : 36, normal pentamerous mid tarsi; 37 & 38, stages in the fusion of the mid tarsal segments along their dorsal margin; 39, four-merous mid tarsi; 40, a stage in the fusion and reduction of the hind tarsal segment; 41, normal pentamerous hind tarsi.

submedian lobes separated from each other by a median shallow notch; anterior part of the frontal region with a distinct funnel-like notch, the limb of which reaches the posterior margin; eyes small, lateral, anterior. Antenna (Fig. IV, 30) four-segmented; radicle longer than wide; scape stout, compressed, less than twice as long as wide, with a few sensillae; second segment wider distally, longer than wide; third segment small, annular, its proximal half well chitinised, distal half submembranous; fourth slightly narrowed towards apex, longer than scape but a little less wide, its apical portion differentiates into a distinct subhemispherical piece bearing a number of thick and ovoid sensory rods. Mandible (Fig. IV, 31) one and a half times as wide as long, small, unidentate, with a small dentiform angular projection ventrally.

Thorax (Fig. IV, 32): Pronotum about as long as wide, wider posteriorly, lateral margins concave and converging forwards; anterior half of the pronotum with a distinct anterior lobe and with a deep cleft on either side; posterior margin concave. Length of rest of thorax and propodeum a little over the width of its mesonotal region; propodeal spiracles lateral and posterior. Fore legs (Fig. IV, 33): Coxa about twice as long as wide; trochanter indistinct; femur large, a little less than thrice as long as wide. Tibia short, a little more than one and one-third as long as wide; its outer face with setae and with a distal concavity limited basally by a row of long setae, dorsally by four stout and two small dentiform processes, and ventrally by a long seta and by two stout dentiform processes. Tarsi shorter than the tibia; metatarsus slightly shorter than the second segment and with two stout odontoid spines situated on its ventral margin as in figure. Mid leg (Fig. IV, 34): Length of coxa four-fifths its width; trochanter absent; femur about one and one-third as long as wide; tibia shorter than femur, subcompressed, a little less than thrice as long as wide, with setae and odontoid spines on its outer face as in figure. Tarsi distinctly longer than tibia, armed with odontoid spines as in figure; metatarsus shorter than the two following segments combined and a little shorter than the fifth segment. Hind leg (Fig. IV, 35): Coxa a little wider than long, compressed; trochanter absent; femur about one and a half times as long as wide, its dorsal margin strongly projecting behind; tibia a little over half the femur, subcompressed, narrow basally, widest distally, its outer face with a tridentate apex, odontoid spines and setae as in figure. Tarsi one and one-third as long as the tibia, armed with odontoid spines as in figure, metatarsus shorter than the two following segments combined and equal to the fifth segment.

Abdomen: Length two and a half times width.

Measurements. Length of body: 2.3 mm.; length of head: 0.33 mm.; width of head: 0.34 mm.; length of pronotum: 0.51 mm.; width of pronotum: 0.53 mm.; length of rest of thorax and propodeum: 0.55 mm.; width of mesonotal region: 0.51 mm.; length of abdomen: 1.19 mm. ; width of abdomen: 0.47 mm.

Holotype female dissected on slides Nos. 23/6-1, 23/6-2, 23/6-3, 23/6-4 and 23/6-5; *allotype* male dissected on slides Nos. 23/8-1, 23/8-2 and 23/8-3. *Paratypes* four females and several males in spirit.

Collected by K. J. Joseph from the figs of *Ficus mysorensis* Hayne from Thalakvady, Belgaum, 17-vi-1953.

E. koningsbergeri Grandi

1917. *Eupristina koningsbergeri*, GRANDI, *Boll. Lab. Zool. Portici*, **12** : 52-56.

I refer to this species several females and males, on slides and in spirit, collected by K. J. Joseph from the figs of *Ficus benjamina* Linn. from the Forest Research Institute Estate, New Forest, Dehra Dun, 29-vi-1953.

Grandi (*loc. cit.*) studied this species from Java. I record here the species for the first time from India.

DESCRIPTIONS OF FIVE NEW AND RECORDS AND REDESCRIPTIONS OF TWO KNOWN BETHYLOIDEA (PARASITIC HYMENOPTERA) FROM INDIA*

By Chandy Kurian, M. Sc., F. R. E. S., *Research Associate, School of Entomology, St. John's College, Agra.*

The type specimens of the new species described here are for the time being retained in the collection of the School of Entomology. The material dealt with in this paper belongs in part to the College of Agriculture, Dharwar; Technical Development Establishment, Laboratory (Stores), Kanpur; Government Entomologist, Bangalore; Forest Research Institute, Dehra Dun and Central Rice Research Institute, Cuttack. Some specimens were also reared by me in the School of Entomology.

Two genera *Trissomalus* and *Odontepyris* are being recorded for the first time from India, while three other species are new to science. *Laelius voracis* Muesebeck and *Pseudogonatopus sogatea* Rohwer are redescribed.

I take this opportunity of expressing my sincere thanks to Dr. M. S. Mani, Professor of Zoology and Entomology, School of Entomology, St. John's College, Agra, for facilities for work and guidance and to the authorities of the various institutions mentioned above for loan of material for study and for other courtesies.

Superfamily BETHYLOIDEA

Family Dryinidae

Subfamily Gonatopodinae

Pseudogonatopus sogatea Rohwer

1920. *Pseudogonatopus sogatea*, Rohwer, *Proc. U. S. Nat. Mus.*, 57 : 160.
1920. *Pseudogonatopus sogatea*, Misra, *Mem. Dept. Agric. Ind.*, (*Ent. Ser.*), 5(5) : 207-239.
1942. *Pseudogonatopus sogatea*, Pruthi and Mani, *Mem. Indian Mus.*, 13(4) : 426-427, fig. 18 & 19.
1954. *Pseudogonatopus sogatea*, Kurian, *Agra Univ. J. Res.* (*Sci.*), 3(1) : 258-259.

---

*Contribution No. 47 from the School of Entomology, St. John's College, Agra, published with the permission of the Professor of Zoology and Entomology.

To this species I refer 1 male and 2 females bred at Cuttack, Orissa, by P. Israel on Jassids. This is formerly known to parasitise nymphs of Delphacid paddy leaf-hoppers *Sogatea pusana* Dist., *Sogatea distincta* Dist. and *Sogatea pallescens* Dist.

Since the original descriptions and drawings are in many respects inadequate and inaccessible to many Indian workers, I am giving below a detailed description with illustrations of both the sexes.

Female.—Length 3.0 mm. Colour dark reddish-brown to black. Head reddish-brown; viewed from above length about half the width of the head; interorbital distance two-thirds the width of the head; width of eye nearly one and a half times the post-orbital distance; vertex broad, black, rugosely sculptured, with very short silvery-white pubescence, laterally bulging, somewhat depressed medially, emarginate; ocelli brownish-white, arranged in an equilateral triangle; interocellar distance two-fifths the ocellocular, which latter is two and a half times the front ocellar; eyes concolouress with ocelli, bare; viewed in front length two-thirds the width of the head; interorbital distance somewhat more than half the width of the head; length of eye three and a half times that of gena; post-orbital short, one-seventh the length of eye. Frons and face somewhat depressed, rugosely sculptured, reddish-brown, but the former darker; face with a carina starting in between the insertion of the antennae and running up to the front ocellus; inner orbital borders faintly carinate and posteriorly diverging; clypeus reddish-brown, slightly convex, apically rounded, finely rugosely sculptured; mandibles reddish-brown, 4-dentate, with dark reddish-brown teeth, first two teeth acute, rest blunt. Antenna inserted below the middle of the face, above the clypeus on either side, on or just below an imaginary line joining the lower orbital borders; reddish-brown; 10-segmented; scape, pedicel and eight jointed flagellum; scape one and one-third the pedicel; first flagellar joint thrice the pedicel and twice the scape; second one-third the first and equal to the pedicel; rest of the flagellar joints except the terminal very gradually become shorter or are subequal to the second; terminal slightly less than twice the penultimate (Fig. 4).

Thorax: Dark reddish-brown; length four times the width; pronotum finely rugosely sculptured, with a transverse depression

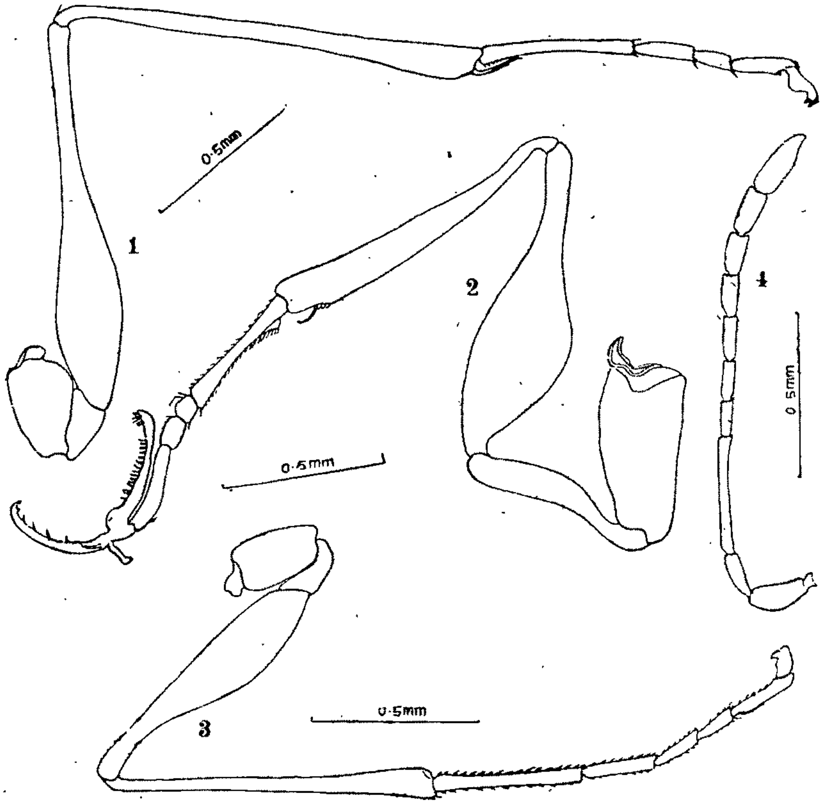


FIG. 1 - 4. *Pseudogonatopus sogatea* Rohwer, female 1. hind leg, 2. fore leg, 3. mid leg, 4. antenna.

about half of the distance from the anterior end; pronotal expansions somewhat prominent; anterior region of the prothorax somewhat neck-like, mesonotum and scutellum invisible, tegulae and wings wholely absent; rest of thorax fused and the different parts indistinguishable, rugosocarinately sculptured; propodeal area posteriorly narrowing; propodeal spiracles medium sized, broadly oval, with a carinate rim. Legs reddish-brown. Fore coxa equal to trochanter, latter slightly more than half the femur; tibia slightly less than the femur; metatarsus slightly less than half the tibia and six-sevenths the rest of tarsi combined, excluding the last tarsus developed as the chela; fourth tarsal segment long, nearly three-fourths the metatarsus; fore and mid legs as in fig. 2 & 3. Hind coxa slightly less than twice the trochanter; femar six times the trochanter; tibia one and one-seventh the femur; tibial spur one-seventh the tibia and slightly more than two-fifths the metatarsus; metatarsus one-third the tibia and five-eighths the rest of tarsi combined (Fig. 1). Abdomen somewhat more than half the length of thorax; petiolate; petiole nearly one-fourth the whole length of abdomen; broadly oval or nearly round, apically somewhat truncate; tergites nearly smooth and shiny; first tergite much longer than the rest, rest of tergites gradually become shorter; third tergite the broadest, beyond which the abdomen abruptly narrows; ovipositor-sheath short, nearly as long as the last tergite; ovipositor not exserted.

Male.—Length 2.0 mm. Colour reddish-brown. Head viewed from above length slightly less than half the width; interorbital distance four-sevenths the width; width of eye twice the post-orbital; vertex distinctly rugosely sculptured, posteriorly with many foveae arranged in a line beyond which is the carina, which continues laterally; ocelli arranged in a triangle; interocellar distance two-thirds the ocellocular, which latter is nearly twice the front ocellar; eyes brown, bare; viewed in front length somewhat shorter than the width; interorbital distance very slightly less than half the width of the head; length of eye somewhat over twice that of gena; post-orbital distance slightly less than one-third the length of eye; frons and face reddish-brown, rugosoreticulately carinate; inner orbital border with many foveae arranged in a line; clypeus same colour as the face, slightly convex, apex somewhat rounded, faintly and finely sculptured with very short white pubescence; mandibles reddish-brown, bidentate, both teeth acute and dark reddish-brown. Antenna inserted above the clypeus on either side, below the middle of face, on an imaginary line joining the lower orbital borders; brown, scape lighter than the rest; II-segmented; scape length nearly four times the width, four times the pedicel; first flagellar thrice the pedicel; second and remaining flagellar segments gradually become shorter, until the penultimate is very slightly over three-fourths the first flagellar; terminal nearly two-thirds the scape, two and a half times the pedicel and five-sixths the first flagellar (Fig. 8).

Thorax: Length somewhat over one and one-fourth the width; pronotum invisible above; mesonotum long, rugosely sculptured, with a median longitudinal fovea and distinct parapsidal furrows; rest of thorax except propodeum nearly the same length as mesonotum; sculpture same as mesonotum; two distinct

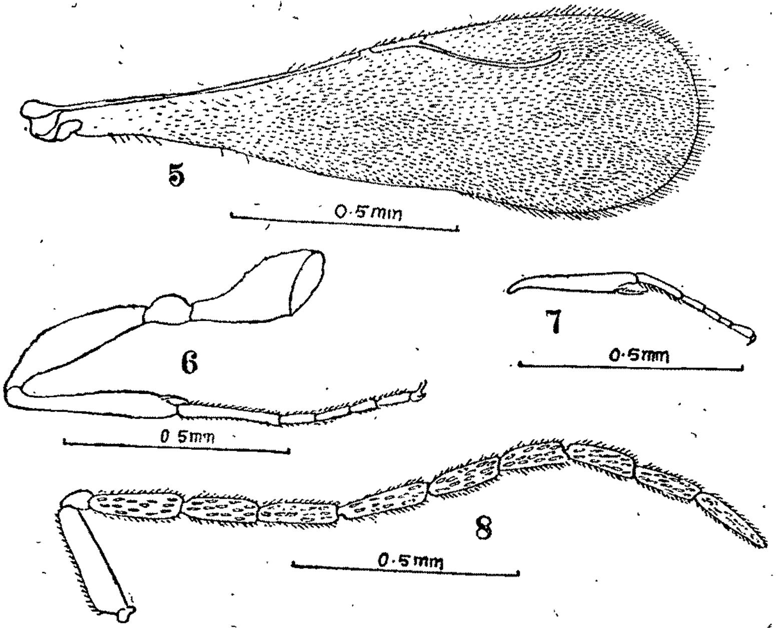


FIG. 5 - 8. *Pseudogonatopus sogatea* Rohwer. male 5 fore wing, 6. hind leg, 7. part of fore leg, 8. antenna.

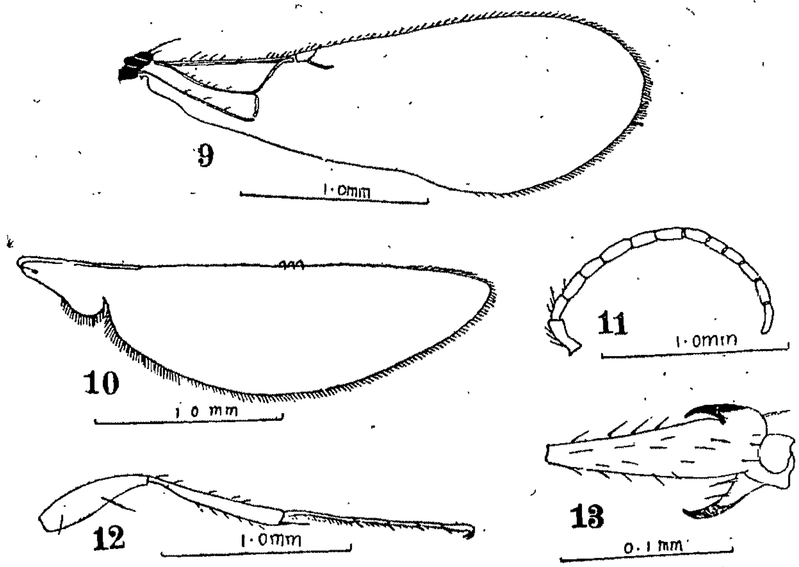


FIG. 9 -13. *Laelius voracis* Muesebeck. male 9. fore wing, 10. hind wing, 11. antenna, 12. hind leg excluding coxa and trochanter, 13. claw of hind leg enlarged.

and deep furrows present, which contain many deep punctures; propodeum half the mesonotum, rugosoreticulately sculptured;

propodeal spiracles medium sized and round. Legs reddish-brown, with lighter tarsi. Fore coxa twice the trochanter, latter nearly one-third the femur; tibia equal to femur; tibial spur one-fourth the tibia; metatarsus nearly two-thirds the tibia and slightly less than the rest of tarsi combined (Fig. 7). Hind coxa thrice the trochanter, latter two-sevenths the femur; femur three and a half times the trochanter; tibia slightly longer than femur; tibial spur nearly one-sixth the tibia and one-fourth the metatarsus; metatarsus slightly more than five-eighths the tibia and five-sixths the rest of tarsi combined (Fig. 6). Fore wing length slightly over thrice the breadth; pterostigma very narrow and vein-like; subcosta and costa coalesced; radial slightly over twice the pterostigma (Fig. 5). Abdomen reddish-brown, darker dorsally; nearly the same length as thorax.

Family BETHYLIDAE

Subfamily Sclerodermínae

Laelius voracis Muesebeck

1939. *Laelius voracis*, MUESEBECK, *Biol. Soc. Washington Proc.*, **52** : 172.
1940. *Laelius voracis*, MUESEBECK, *Proc. ent. Soc. Washington*, **42** : 110.
1951. *Laelius voracis*, MUESEBECK and Walkley, *U. S. Dept. Agric.* (*Agric. Mon.*), **2** : 728.
1954. *Laelius voracis*, KURIAN, *Agra Univ. J. Res.* (*Sci.*), **3**(1) : 265.

To this species I refer many males and females bred at Technical Development Establishment, Laboratory (Stores), Kanpur, by T. S. Subramanian on larvae of *Anthrenus vorax* Waterh. (wooly-bear). This has formerly been recorded from North America by Muesebeck.

This is being recorded for the first time from India.

Male.—Length 3.0—3.75 mm. Colour black. Head somewhat flattened, but nearly globose, with leathery sculpture, covered over by scattered, long, brownish-black pubescence; eyes large, dark brown and bare; viewed from above as broad as long, posteriorly narrowed behind the eyes; ocelli prominent, yellowish-brown, arranged in a broad triangle, anterior one being placed in a shallow depression; interocellar distance twice the front ocellar, which latter is one-fourth the ocellocular; viewed in front length slightly more than the width; interorbital distance two-thirds the width of the head; clypeus prominent with a longitudinal carina in the middle; length of gena nearly equal to that of eye; mandibles dark reddish-brown. Antenna one and a half times the length of the head, inserted below the middle of the face, below an imaginary line joining the lower orbital borders, on either side of the clypeus; dark reddish-brown except for the lighter scape, pedicel and first flagellar joint; scape with a few medium sized brownish-black setae, much longer than broad, length nearly equal to pedicel and first flagellar combined; first flagellar slightly longer than the pedicel; second longer than the first; third and succeeding joints gradually become shorter; terminal joint one and one-third the penultimate (Fig. 11).

Thorax: Shorter than abdomen, black, rugosoreticulately sculptured, with few, long, scattered setae; prothorax narrowed anteriorly; mesothorax longer than prothorax, parapsidal furrows posteriorly distinct; scutellum convex, with a deep groove anteriorly; propodeum as long as mesothorax and scutellum combined; anterior area carinate on all sides, with five longitudinal carinae, reticulately sculptured; posterior area steep. Legs reddish-brown except for black coxae. Fore tibia shorter than femur. Hind tibia much longer than femur and nearly equal to the tarsal joints combined; tibial spurs short and sharp, the longer twice the shorter, claw simple (Fig. 12 & 13). Fore wings two and a half times as long as broad, venation much reduced, with two basal cells and a short radial vein; veins armed with bristles; radial shorter than basal; pterostigma very small; rest of details and hind wing as in fig. 9 & 10. Abdomen smooth and shiny; six tergites distinctly visible, second the biggest, rest of them gradually become shorter, sixth tergite apically conically narrowed; distal half of third, fourth, fifth and sixth segment with pubescence.

Female.—nearly same as in the male.

Subfamily Epyrinae

Chlorepyris sancti-pauli, sp. nov.

Female.—Length 4.5 mm. Colour black. Head black; completely prognathous; vertex narrow, emarginate, finely rugoso-coriaceously sculptured and with few silvery-brown setae mostly disposed posteriolaterally; ocelli dark reddish-brown, arranged in a somewhat broad triangle, interocellar space one and three-fourths the ocellocular, which latter is slightly over three times the front ocellar; viewed in front length very slightly less than the width; interorbital distance three-fourths the width of the head at the middle of the eye; length of eye nearly nine times that of gena; post-orbital distance same length as eye; frons and face finely coriaceously sculptured, with a few, scattered, shallow, but broad punctae; eyes brownish-black, bare; mandible reddish-brown, strong, teeth blunt, arising from just below the lower orbital borders; clypeus slightly convex, somewhat conical, basally black, apically reddish-brown, covered over by short, silvery-brown setae. Antenna inserted on either side of the clypeus, just above the mouth, below an imaginary line joining the lower orbital borders; 13-jointed; scape length two and two-thirds the width, two and two-thirds as long as the pedicel; pedicel length one and one-third the width; all flagellar joints longer than broad; first flagellar very slightly more than half the pedicel; second flagellar equal to the pedicel; third and succeeding segments equal to second, except the terminal, which is slightly less than one and a half times the penultimtae and very slightly more than half the scape (Fig. 16).

Thorax: Length thrice the width at the region of the tegulae; pronotum long, posteriorly broader than mesonotum, finely coriaceously sculptured, with a shagreened appearance, with few, shallow, broad punctae, from which silvery-white hairs are given off; mesonotum slightly more than one-third the pronotum, with few shallow punctae and hairs and also two lateral foveae, which are distinct only anteriorly; parapsidal furrows distinct and complete, anteriorly fainter and posteriorly broadening into sort of foveae; scutellum somewhat longer than mesonotum, convex, very finely coriaceously sculptured or nearly smooth and shiny, posteriorly with two long silvery-white setae on either side and two small nearly oval foveae anteriolaterally disposed; metathorax short and indistinct; propodeum somewhat longer than pronotum and very slightly longer than one and one-third the mesonotum, scutellum and metathorax combined; divided by a transverse carina into an anterior horizontal area and posterior slanting part; with five longitudinal carinae, one medial and four lateral, two on either side; in addition are the lateral marginal carinae, which run down and continue the slanting posterior area of the propodeum as basal carina; median longitudinal carina continue right down to the very tip of the propodeum; longitudinal carinae are interconnected by many irregular transverse carinae, giving the medial area of the propodeum a reticulately sculptured appearance; rest of propodeum irregularly rugoso-coriaceously sculptured; propodeal spiracles medium sized, narrow and lanceolate. Legs reddish-brown, covered over by long spiny hairs. Fore coxa two and a half times the trochanter; femur nearly five times the latter; tibia two-thirds the femur; tibial spur nearly one-third the tibia; metatarsus half the tibia and two-thirds the rest of tarsi combined; apex of tibia and tarsi beset with long spines (Fig. 18). Hind coxa slightly over twice the trochanter; femur somewhat over thrice the trochanter; tibia one and one-tenth the femur; tibial spurs longer half the tibia and shorter two-thirds the longer; metatarsus two-thirds the tibia and very slightly less than two-thirds the rest of tarsi combined; apex of tibia and tarsi beset with spinous setae; claw bifid (Fig. 17). Fore wing length very slightly less than thrice the breadth; costa and subcosta distinct and separate; radius one-seventh the length of the wing and twice as long as pterostigma; pterostigma length one and two-thirds the width; basal vein half the radius; transversal slightly shorter than basal; rest of details and hind wing as in fig. 14 & 15. Abdomen reddish-brown to black, apex lighter in colour; indistinctly petiolate, petiole very short; somewhat longer than thorax; six tergites distinctly visible, tergites nearly smooth and shiny, except for fine coriaceous sculpture basally and few moderately long silvery-brown setae arranged mostly at the apex; tergites nearly subequal, third the largest and the last two somewhat shorter than the rest; ovipositor very slightly exserted, nearly as long as the ovipositor-sheath.

Holotype female partly dissected on slide No. 142/B and rest on pin, labelled : "On wing, St. Paul's Church, Agra, 22-vii-1951, Coll. Chandy Kurian".

This species comes close to *Chlorepyris raripilus* Kieffer, but is easily distinguished by the propodeum being distinctly longer than wide; apically conically rounded pterostigma and reddish-brown scape.

Key to species (Oriental)*

1. Claw with one tooth; mandible with four teeth................................ *unidens* Kieffer

Claw bidentate; mandible with one to five teeth.................................. 2

2. Claw bidentate; mandible with one or two teeth.............................. 3
Claw bidentate; mandible with three teeth.. *conjunctus* (Kieffer)

Claw bidentate; mandible with five teeth.. *flavipennis* Kieffer

3. Propodeum somewhat elongate, scarcely longer than broad, with five contiguous longitudinal carinae, only the median carina reaching the posterior margin; pterostigma truncate distally; scape blackish-brown......................... *raripilus* Kieffer

Propodeum somewhat elongate, distinctly longer than broad with five contiguous longitudinal carinae, only the median carina reaching the posterior margin; pterostigma apically conically rounded; scape reddish-brown......... *sancti-pauli*, sp. nov.

Propodeum somewhat transverse, with five contiguous and continuous longitudinal carinae; pterostigma distally tapering....................................... *raptor* Kieffer

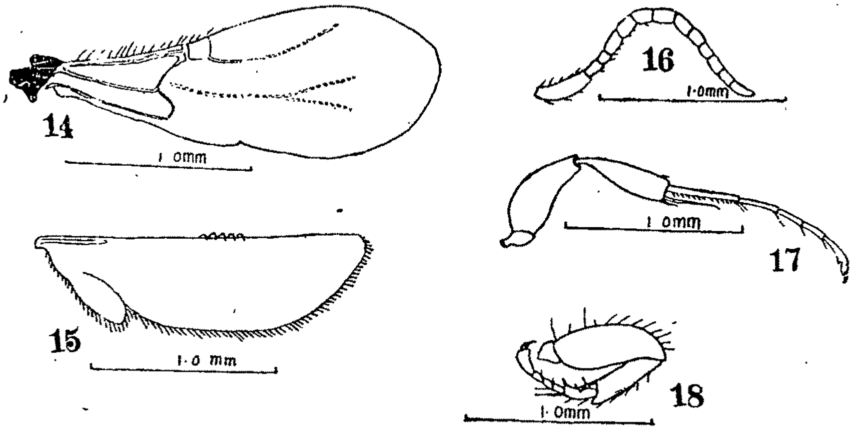
Subfamily Bethylinae

Trissomalus indicus, sp. nov.

Female.—Length 5.3 mm. Colour black. Head viewed from above length slightly more than half the width; interorbital distance five-eighths the width of the head; post-orbital distance somewhat less than the width of the eye; eyes brown, with few, short, fine, scattered pubescence; vertex finely and distinctly rugosely sculptured, with few, scattered, silvery-white pubescence; emarginate; ocelli reddish-brown, arranged in a triangle; interocellar distance slightly more than two-fifths the ocellocular, which latter is three and a half times the front ocellar; viewed in front length slightly more than seven-eighths the width; interorbital distance somewhat less than two-thirds the width of the head; length of eye thrice that of gena and somewhat more than twice the post-orbital distance. Frons and face finely rugosely sculptured with some shallow depression, from which silvery-white setae are given off; clypeus beak-like, apex conical, with nearly the same sculpture as the face, with a median longitudinal carina, which

---

*Key to species described from oriental region previously to include the newly discovered form.



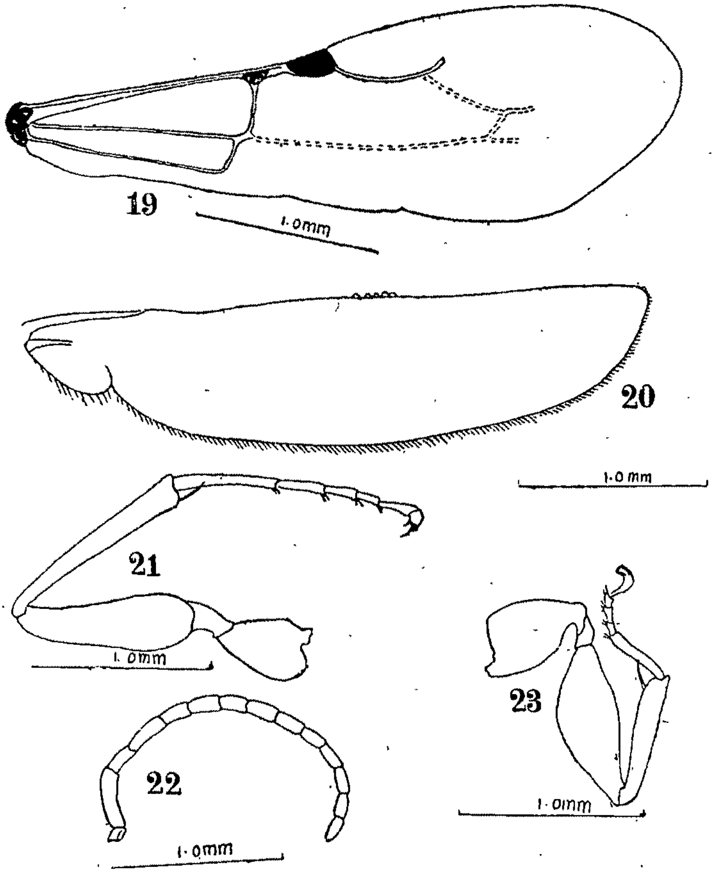


FIG. 14-18. *Chlorepyris sancti-pauli*, sp. nov. female 14. fore wing, 15. hind wing, 16. antenna, 17. hind leg excluding coxa, 18. fore leg excluding coxa.

FIG. 19-23. *Trissomalus indicus*, sp. nov. female 19. fore wing, 20. hind wing, 21. hind leg, 22. antenna, 23. fore leg.

runs up to a level about the lower orbital borders and then continue as a faint fovea up to the front ocellus; mandible reddish-brown, strong set, four toothed, teeth acute. Antenna dark reddish-brown to black; inserted far below the middle of the face, below an imaginary line joining the lower orbital borders, on either side of the clypeus; 13-jointed; scape two and one-fourth the pedicel; first flagellar slightly shorter than one and a half times the pedicel; second and succeeding segments gradually become shorter until the terminal which is one and one-fourth the penultimate and half the scape (Fig. 22).

Thorax: Length two and one-fifth the width at the region of the tegulae; pronotum nearly one-fourth the whole length of the thorax, finely rugosely sculptured, with short silvery-white pubescence; mesonotum as long as pronotum, rugosocoriaceously sculptured, with a somewhat shagreened appearance; parapsidal furrows distinct and deep posteriorly and gradually become vague and indistinct anteriorly; tegulae reddish-brown; scutellum three-sevenths the mesonotum, with very faint sculpture giving an indistinctly shagreened appearance, nearly smooth and shiny, with two deep pits anteriolaterally; metathorax one-third the scutellum, grooved; propodeum in the anterior horizontal area reticulately carinate medially and coriaceously carinate laterally; there is a median longitudinal carina running up to the transverse carina separating the horizontal anterior area from the slanting posterior part; the slanting posterior area has a shagreened sculpture; posterior and lateral carina complete and very distinct; propodeal spiracles large, lanceolate. Legs reddish-brown. Fore coxa two and one-fifth the trochanter; femur four and two-thirds the latter; tibia nearly four-fifths the femur; tibial spur one-fourth the tibia and half the metatarsus; metatarsus half the tibia and slightly shorter than the rest of tarsi combined (Fig. 23). Hind coxa twice the trochanter; femur five and three-fourths the latter; tibia one and one-sixth the femur; tibial spur one-fifth the tibia; metatarsus half the tibia and four-fifths the rest of tarsi combined (Fig. 21). Fore wing length twice the breadth; radial vein slightly less than one-sixth the length of the wing; basal somewhat less than half the radial; transversal slightly more than half the basal; rest of details and hind wing as in fig. 19 & 20. Abdomen black, as long as or slightly longer than thorax, with a very short petiolar constriction; smooth and shiny, with five visible tergites; first tergite the largest, rest of them gradually become shorter; ovipositor-sheath short and ovipositor only slightly exserted.

Holotype female partly dissected on slide No. 141/B and rest on pin labelled: "On sugarcane borer, Bangalore, 16-ix-1950, Coll: B. Krishnamoorti".

This is the first record of the genus from India.

Perisierola pulveriae, sp. nov.

Female.—Length 3 0 mm. Colour brownish-black. Head viewed from above length somewhat more than half the width; interorbital distance very slightly over three-fourths the width; width of eye somewhat more than the post-orbital distance; vertex rugosely sculptured, with a coriaceous appearance in certain angles, nearly emarginate; ocelli dark reddish-brown, arranged in a triangle; interocellar distance slightly over two-fifths the ocellocular, which latter is three and three-fourths the front ocellar; eyes concolouress with the head, bare; viewed in front length somewhat more than the width; interorbital distance three-fifths the width of the head; length of eye six times that of gena; post-orbital distance slightly less than two-thirds the length of eye; frons and face distinctly rugosely sculptured, with few, distinct, shallow punctae somewhat uniformly scattered; clypeus somewhat beak-like with a median longitudinal carina running up to a level about one-third the length of eye, with two short, white setae laterally placed; a few long silvery-white setae disposed laterally on the temples and vertex; mandibles strong set, concolouress with the head, with few silvery-white setae basally. Antenna inserted on either side of the clypeus, below an imaginary line joining the lower orbital borders; honey-brown, apex slightly darker; 13-segmented; scape very slightly over twice the pedicel, length slightly over one and a half times the width; first flagellar segment seven-eighths the pedicel, rest of flagellar segments very gradually become shorter until the terminal segment is one and a half times the penultimate, slightly more than half the scape and one and one-fifth the pedicel (Fig. 28).

Thorax: Length slightly over twice the width; pronotum large, anteriorly narrowing, faintly rugosely sculptured, with a shagreened appearance; having few, faint, shallow punctures scattered all over, as also a few short, white setae mostly arranged anterio-laterally; mesonotum two-fifths the pronotum, sculpture same as pronotum; parapsidal furrows shallow, but distinct and complete; scutellum very slightly longer than mesonotum, with short anteriolateral foveae, one on either side, sculpture almost the same as mesonotum, but somewhat coriaceously sculptured posteriorly; metathorax short, one-fourth the scutellum, sculpture same as scutellum, but somewhat irregular, with two fovaeae on either side, outer much bigger than inner; propodeum equal to mesonotum, scutellum and metathorax combined, rugosocoriaceously sculptured, with a faint transverse carina, differentiating the anterior horizontal area from the posterior slanting part; anterior portion with a median longitudinal raised ridge-like area reaching up to transverse carina, lateral carina continuing in the slanting part of the propodeum; propodeal spiracles small and lanceolate. Legs honey-brown except for darker coxae and femora. Fore coxa nearly two and a half times the trochanter; femur slightly over four times the trochanter; tibia somewhat over two-thirds the femur; metatarsus slightly less than half the tibia, latter twice the rest of tarsi combined (Fig. 25). Hind coxa two and a half times the trochanter; femur slightly over four times the trochanter; tibia somewhat longer than femur; tibial spur a little less than one-third the tibia, which latter is nearly twice the metatarsus; metatarsus slightly less than two-thirds the rest of tarsi combined (Fig. 27). Fore wing length two and two-thirds the breadth; prostigma and pterostigma distinct; pterostigma length twice the breadth, one and a half times the prostigma; costa and subcosta somewhat confluent; radius distally, distinctly bend upwards, with a somewhat smooth curve; radial twice the length of pterostigma; basal stalk of basal one-sixth the radial and equal to the breadth of prostigma; anterior branch of basal one and one-fourth the basal stalk of basal; posterior branch one and a half times the anterior; transversal nearly three-fourths the posterior branch of basal; rest of details and hind wing as in fig. 24 & 26. Abdomen dark reddish-brown to black, somewhat shorter than thorax; tergites nearly smooth and shiny; six tergites distinctly visible; first two tergites much longer than the rest; tergites laterally with silvery-white setae; ovipositor-sheath as long as the last tergite; ovipositor not much exserted.

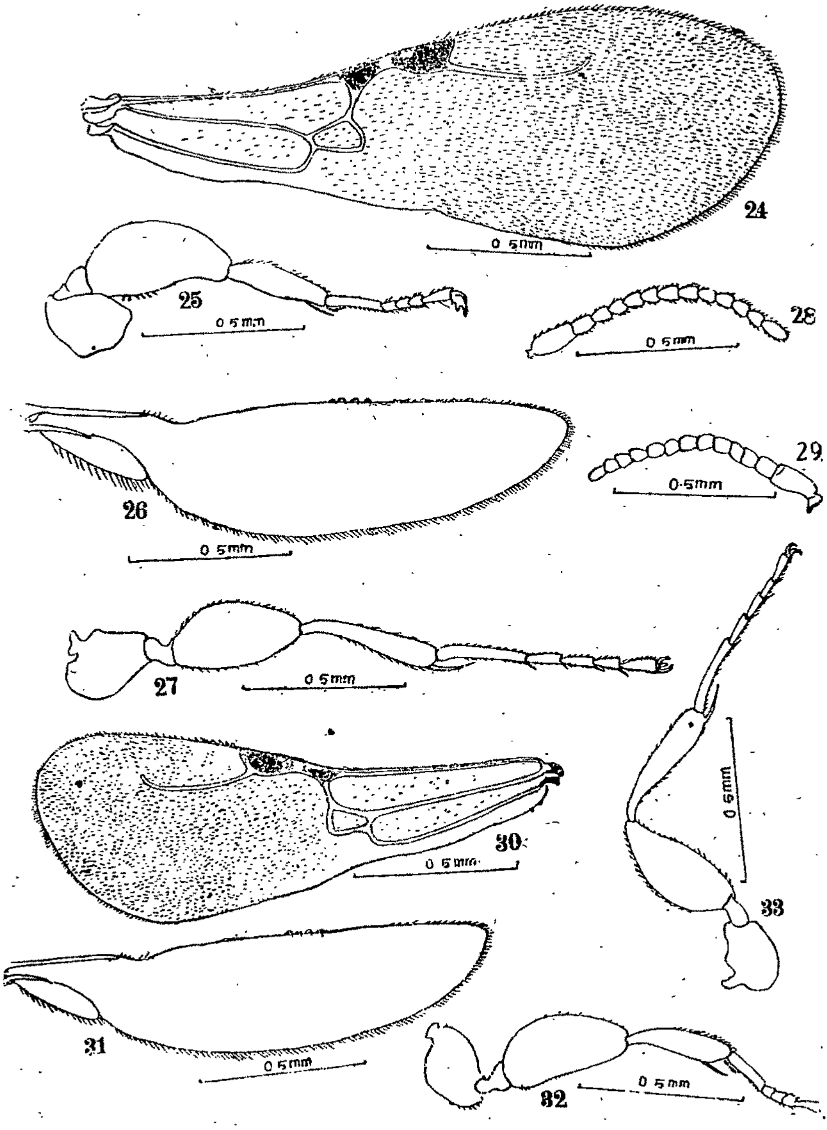


FIG. 24-28. *Perisierola pulveriae*, sp. nov. female 24. fore wing, 25. fore leg, 26. hind wing, 27. hind leg, 28. antenna.

FIG. 29-33. *Perisierola pulveriae*, sp. nov. male 29. antenna, 30. fore wing, 31. hind wing, 32. fore leg, 33. hind leg.

Male.—Length 2.4 mm. Colour brownish-black. Head viewed from above length four-sevenths the width; interorbital distance three-fourths the width of the head; width of eye one and one-third the post-orbital distance; vertex with a faint margin visible only medially and not laterally; ocelli dark reddish-brown; interocellar distance slightly less than half the ocellocular, latter being four times the front ocellar; eyes concolouress with the head, bare; viewed in front length somewhat more than the width; interorbital distance very slightly less than two-thirds the width of the head; length of eye six times that of gena and one and a half times the post-orbital distance; frons and face rugosely sculptured, with few, shallow, scattered punctures; clypeus somewhat beak-like, with a median longitudinal carina running posteriorly upto a level of about one-third the length of eye, with a few, short, silvery-white setae laterally placed; mandibles strong, brownish-black, with apices of teeth dark reddish-brown. Antenna inserted on either side of the clypeus, below an imaginary line joining the lower orbital borders; reddish-brown, darker towards the apex; 13-segmented; scape length one and one-third the width, very slightly less than twice the pedicel and a little less than the pedicel and first flagellar combined; first few flagellar segments vase shaped, rest of them fast become moniliform; first flagellar segment two-fifths the scape and slightly over two-thirds the pedicel; rest of flagellar segments very gradually become shorter until the penultimate is two-thirds the pedicel; terminal half the scape and nearly equal to the pedicel (Fig. 29).

Thorax: Length slightly more than one and three-fourths the width; pronotum large, anteriorly narrowing; rugosely sculptured, with few, faint, shallow punctate and a few setae posteriolaterally placed; mesonotum slightly less than half the pronotum, sculpture same as latter; parapsidal furrows shallow, but distinct and complete; tegulae reddish-brown; scutellum very slightly more than the mesonotum, sculpture same as mesonotum, with two anterior and two posterior foveae laterally placed; metathorax very short, with an irregular sculpture; propodeum very slightly more than mesonotum, scutellum and metathorax combined; a faint transverse carina demarcate the anterior horizontal area from the posterior slanting part; anterior part having a median longitudinal elevation continuing upto the transverse carina and also bounded by the lateral carinae which stop at the transverse carina; propodeal spiracles small and lanceolate. Legs honey-brown. Fore coxa twice the trochanter, the latter one-fourth the femur; tibia three-fourths the femur; tibial spur two-sevenths the tibia and five-eighths the metatarsus; metatarsus half the tibia and slightly shorter than the rest of tarsi combined (Fig. 32). Hind coxa slightly over twice the trochanter; femur three and two-thirds the trochanter; tibia one and one-seventh the femur; tibial spur one-fourth the tibia and very slightly less than half the metatarsus; metatarsus a little less than half the tibia (Fig. 33). Fore wing length two and three-fourths the breadth; pterostigma slightly longer than prostigma, length nearly twice the breadth; subcosta and costa somewhat confluent; radial long, somewhat over twice the length of pterostigma, apex of radial somewhat smoothly curved; basal stalk of basal nearly one-sixth the radial; anterior branch of basal slightly longer than the basal stalk of basal; posterior branch one and a half times the anterior; transversal two-thirds the posterior branch of basal; rest of details and hind wing as in fig. 30 & 31. Abdomen dark reddish-brown; nearly as long as thorax; seven tergites distinctly visible; tergites nearly smooth and shiny, with a few silvery-white setae mostly arranged laterally; first four tergites much larger than the rest, second the largest.

Holotype female partly dissected on slide No. 143/B and rest on pin, labelled: "Ex. *Holcocera pulverea*, predator on *Tachardia lacca*, P. M. Glover, Dehra Dun, 10-i-1938"; *allotype* male partly dissected on slide No. 144/B and rest on pin, with the same label dated 24-ii-1937.

This species bears a general resemblance to *Perisierola nephantidis* Muesebeck, from which it is readily distinguished by the ocellocular being two and one-third the interocellar; scape one and a half times as long as broad; first discoidal cell less than twice as long as broad; completely yellowish-brown femora and brownish-black mandibles in both the sexes.

Perisierola salvadorae, sp. nov.

Female.—Length 2.0—2.2 mm. Colour black, except for honey-brown to dark reddish-brown legs. Head viewed from above length half the width; interorbital distance slightly more than four-fifths the width of the head; width of eye one and one-fourth the post-orbital distance; ocelli dark reddish-brown, arranged in a broad triangle; interocellar distance twice the front ocellar, which latter is very slightly shorter than half the ocellocular; vertex finely rugosocoriaceously sculptured, nearly emarginate, with a faint margin posterior to which the occiput is suddenly declivous and somewhat excavate; viewed in front length nearly one and one-fourth the width of the head; interorbital distance nearly two-thirds the width of the head; post-orbital two-thirds the length of eye, which latter is one and two-thirds the length of gena; eyes dark brownish-black, bare; frons and face finely rugosocoriaceously sculptured, with a leathery appearance; clypeus apically conically rounded, with a median carina running upto a level slightly above the insertion of antenna; mandibles concolouress with head, 4-dentate, teeth dark reddish-brown. Antenna reddish-brown, apex darker, covered over by short, silvery-brown setae; inserted on an imaginary line joining the lower orbital borders; 13-segmented; scape somewhat less than twice as long as thick, nearly twice as long as pedicel; pedicel length very slightly less than one and a half times the width; first flagellar one-third the scape and two-thirds the pedicel; second and following flagellar joints very gradually become longer and then shorter, until the penultimate joint is nearly equal to first flagellar; terminal joint somewhat longer than half the scape, very slightly longer than pedicel and one and a half times the penultimate joint (Fig. 34).

Thorax: Length twice the width at the region of the tegulae; pronotum anteriorly narrowing into a sort of neck and with a faint transverse line after the anterior one-fifth, rugosocoriaceously sculptured with a fine leathery appearance, sparsely covered over by silvery-brown pubescence; mesonotum one-third the pronotum, sculpture nearly same as the latter; parapsidal furrows shallow, distinct and complete; scutellum somewhat longer than mesonotum, very finely longitudinally coriaceously sculptured, somewhat smooth and shiny; metathorax short, one-third the scutellum; propodeum very slightly longer than pronotum and somewhat longer than scutellum, metathorax and mesonotum combined; finely rugosocoriaceously sculptured, with a faint reticulate leathery appearance, except for the smooth and shiny area medially; lateral and basal carina present, lateral continuing in the posterior slanting part and then transversely running as basal carina; there is a faint and irregular transverse carina differentiating the anterior horizontal area from the posterior slanting part; propodeal spiracles small and round. Legs dark reddish-brown, trochanters, tibiae and tarsi being lighter in colour. Fore coxa twice the trochanter; femur three and a half times the trochanter; tibia four-fifths the femur; tibial spur nearly one-third the tibia; metatarsus half the tibia and two-thirds the rest of tarsi combined (Fig. 38). Mid coxa slightly more than twice the trochanter; femur three and three-fourths the trochanter; tibia equal to femur; tibial spur one-fourth the tibia; metatarsus one-third the tibia and very slightly longer than one-third the rest of tarsi combined (Fig. 37). Hind coxa very slightly over twice the trochanter; femur four times the trochanter; tibia slightly longer than femur; tibial spur one-fourth the tibia and half the metatarsus; metatarsus nearly half the tibia and three-fifths the rest of tarsi combined (Fig. 39). Fore wing length two and two-thirds the breadth; subcosta, prostigma and pterostigma dark brown; rest of veins light brown; radial slightly over twice the pterostigma; basal stalk of basal one-fourth the radial and equal to anterior branch of basal; posterior branch of basal one and a half times the basal stalk of basal and anterior branch of basal; transversal equal to basal stalk of basal; pterostigma longer and broader than prostigma, length slightly less than twice the breadth; prostigma seven-eighths the pterostigma, length twice the breadth; first discoidal cell length nearly twice the breadth; rest of details and hind wing as in fig. 35 & 36. Abdomen black, with dark reddish-brown tinge towards the apical margins of the tergites; nearly as long as the thorax; tergites nearly smooth and shiny, except for silvery-brown pubescence mostly arranged posterio-laterally; seven tergites distinctly visible; first two tergites somewhat larger than the rest; rest of them subequal or very gradually become shorter; ovipositor-sheath three-fourths the apical tergite.

Male.—Nearly same as the female, except for slightly shorter size; first discoidal cell length slightly over twice the breadth; radius very slightly less than twice the length of pterostigma and abdomen being only four-fifths the thorax and apialyc truncate.

Holotype female dissected on slide No. 148/B; *allotype* male dissected on slide No. 149/B; *paratypes* many females in spirit labelled: "Bethylid parasites from Psyllid galls on *Salvadora persica*, St. John's College, Agra, 25-xi-1954, Coll: Chandy Kurian".

This species comes near *Perisierola pulveriae* Kurian, but is easily distinguished by the ocellocular distance being only very slightly more than the interocellar; the comparatively dark reddish-brown femora and yellowish-brown mandibles in the males.

Key to the Indo-Australian species of Perisierola*

1. Wings distinctly infumated; pterostigma longer and hardly broader than prostigma; radius sharply angled near apex; propodeum delicately reticulate medially *angulata* Muesebeck

Wings hyaline; pterostigma much longer and broader than prostigma; radius not sharply angled; propodeum polished medially.................................. 2

2. Dorsal face of propodeum margined at apex by a distinct, complete, transverse carina and elevated keel-like down the middle; eyes twice as long as their greatest breadth; mandibles and legs entirely yellow; basal vein broken at about the middle.. *mellipes* Muesebeck

Dorsal face of propodeum not margined at apex or the carina only weakly developed towards the sides and the median longitudinal line not elevated keel-like; eyes definitely less than twice as long as broad; mandibles unusually black, sometimes yellow in male; legs usually more or less piceous or blackish............ 3

3. Basal vein broken at or above the upper third; first discoidal cell as long as broad; median polished area of propodeum extending upon the posterior face; metapleurum delicately reticulate and shiny; all femora completely blackish; mandibles black in both sexes... *emigrata* Rohwer

Basal vein definitely broken below upper third; first discoidal cell twice as long as broad; median polished area of propodeum not extending upon posterior face; apices of anterior femora and middle and posterior femora yellowish-brown; mandible yellow in male.. *nephantidis* Muesebeck

Basal vein not broken at or above the upper third; first discoidal cell less than twice as long as broad; median polished area of propodeum not extending upon posterior face; all femora completely yellowish-brown; mandibles brownish-black.. 4

4. Ocellocular two and one-third the interocellar; scape one and a half times as long as broad; pronotum over twice the mesonotum; all femora completely yellowish-brown; mandibles brownish-black in male also........................ *pulveriae*, sp. nov.

Ocellocular very slightly more than interocellar; scape somewhat less than twice as long as broad; pronotum nearly thrice the mesonotum; all femora dark reddish-brown; mandibles yellowish-brown in male..................... *salvadorae*, sp. nov.

---

*Key to species previously described from Indo-Australian region to include the newly discovered forms.

Odontepyris argyriae, sp. nov.

Female.—Length 5.75 mm. Colour black. Head viewed from above length somewhat half the width; interorbital distance

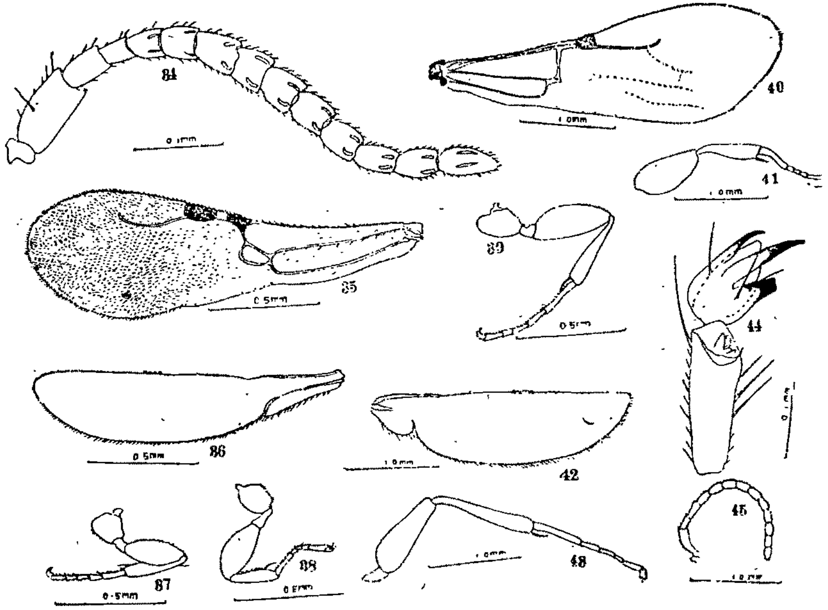


Fig. 34-39. *Perisierola salvadorae*, sp. nov. female 34. antenna enlarged, 35. fore wing, 36. hind wing, 37. mid leg, 38. fore leg, 39. hind leg.

Fig. 40-45. *Odontepyris argyriae*, sp. nov. female 40. fore wing, 41. fore leg excluding coxa and trochanter, 42. hind wing, 43. hind leg excluding coxa, 44. claw of hind leg enlarged 45. antenna.

nearly two-thirds the width of the head; width of eye one and a half times the post-orbital ; eyes dark brown, with very scanty short pubescence or nearly bare; vertex emarginate, rugosely sculptured, with shallow broad punctures irregularly scattered, with silvery-white pubescence, which are longer laterally; Ocelli reddish-brown arranged in a nearly equilateral triangle; ocellocular distance nearly three and a half times the interocellar, which latter is very slightly more than the front ocellar; viewed in front length somewhat less than the width; interorbital distance three-fifths the width of the head; length of eye nearly four times that of gena; post-orbital distance very slightly less than half the length of eye; frons and face rugosely sculptured, with many shallow foveae, scattered somewhat uniformly, from which are given off short hairs; clypeus black, with a median keel-like elevation continuing into face as a faint line upto a length of about one-third the length of eye; mandible strong, dark reddish-brown, 4-dentate. Antenna dark reddish-brown to brownish-black, covered over by silvery-white pubescence; inserted above the mouth, laterally on either side of the clypeus, far below an imaginary line joining the lower orbital borders; 13-jointed; scape length nearly thrice the width, twice the pedicel; first flagellar one and one-fourth, the pedicel; second and succeeding flagellar joints gradually become shorter, except the terminal, which is one and two-fifths the penultimate and slightly longer than half the scape (Fig.45).

Thorax: Black; length nearly two and a half times the width at the region of the tegulae; pronotum transverse, much broader than long, rugosely sculptured, with few, shallow punctae scattered, from which are given off silvery-white hairs, posteriorly expanded, covering the anterior part of the mesonotum; mesonotum length nearly same as pronotum, broader than long, sculpture and setation same as pronotum, tegulae reddish-brown; parapsidal furrows distinct, deep and complete; scutellum short, somewhat convex, faintly rugosely sculptured, with few shallow punctures, nearly smooth and shiny; metathorax slightly less than one-third the scutellum, irregularly sculptured, dull and mostly impunctate; propodeum large, nearly as long as mesonotum, scutellum and metathorax combined; divided by a transverse carina into an anterior horizontal area and posterior slanting part; anterior area roughly irregularly carinate, with many branching transverse carinae, giving a reticulately sculptured appearance; a distinct median longitudinal carina run down to the transverse carina separating the anterior and posterior areas; lateral marginal carina traverse the whole anterior area and continue in the posterior part as the basal carina; propodeal spiracles medium sized and lanceolate. Legs reddish-brown. Fore coxa slightly less than twice the trochanter; femur four times the latter; tibia five-sixths the femur; tibial spur slightly longer than one-fourth the tibia; metatarsus half the tibia and seven-eighths the rest of tarsi combined (Fig. 41). Hind coxa two and one-third the trochanter; femur nearly six times the trochanter; tibia one and one-sixth the femur; tibial spur slightly less than one-fifth the tibia; metatarsus half the tibia and five-sixths the rest of tarsi combined (Fig. 43 & 44). Fore wing length very slightly over thrice the breadth;

radial one-sixth the length of the wing and slightly over two and a half times the length of pterostigma; basal two-fifths the radial; transversal five-eighths the basal; pterostigma length one and one-third the breadth; rest of details and hind wing as in fig. 40 & 42. Abdomen black; length somewhat more than the thorax; nearly sessile; seven tergites distinctly visible ; tergites nearly smooth and shiny, with few faint punctures and silvery-white setae, mostly arranged posterio-laterally; first tergite the largest, rest of them gradually become shorter, last smallest being only one-ninth the first; ovipositor-sheath stout and prominent; ovipositor somewhat exserted; at the apex of ovipositor-sheath, surrounding the ovipositor are stiff brown spines.

Holotype female dissected on slide No. 138/B, labelled: "Parasitic on sugarcane borer, *Argyria sticticraspis*, Dharwar, Coll: S. A. Raja Rao".

This is the first record of the genus from India.

EARLY EMBRYONIC DEVELOPMENT OF *MYLABRIS PUSTULATA* THUNB.

PART II.—CHANGES LEADING TO THE FORMATION OF THE GERM BAND.

By S. R. DEOBHAKTA, M. Sc., *Ministry of Education Research Scholar, School of Entomology, St. John's College, Agra.*

In an earlier paper (2) some preliminary notes on the structure of the egg, cleavage and formation of the germ band in *Mylabris pustulata* Thunb. were published. Since then further detailed studies have been carried out and a fuller account of the cleavage, the formation of the blastoderm, the organisation of the germ band and of the primary dorsal organ is given here. Information regarding the chronological sequence of development at constant temperature of incubation is also included.

I wish to thank Dr. M. S. Mani, Professor of Zoology & Entomology, St. John's College Agra, for guidance and facilities for work.

CLEAVAGE AND FORMATION OF THE BLASTODERM

In the egg fixed immediately after oviposition the zygote nucleus (Fig. I, A, 6) may still be seen in the periplasm, close to the micropylar opening (Fig. I, A, 9). The indications of division of the zygote nucleus appear in the course of the first fifteen minutes of incubation of the fertilized ovum. In the egg fixed after 15 minutes of incubation the zygote nucleus has divided twice and the four daughter nuclei (Fig. I, B, 7) are seen in the reticuloplasm near the anterior end of the egg. From the position of these nuclear fragments it is clear that in the course of the first two nuclear divisions, the zygote nucleus has somewhat shifted posteriorly within the egg. According to Butt (1) the first division of the zygote nucleus begins in *Brachyrhinus ligustici* only after the migration of the zygote nucleus back nearly to the middle of

---

*Contribution No. 48 from the School of Entomology; published with the permission of the Professor of Zoology and Entomology.

the egg and well within the reticuloplasm. The cleavage in *Mylabris pustulata* thus seems to be relatively rapid right from the beginning. While Butt (1) describes the persistance of the polar bodies even upto the blastoderm formation in the parthenogenetic eggs of

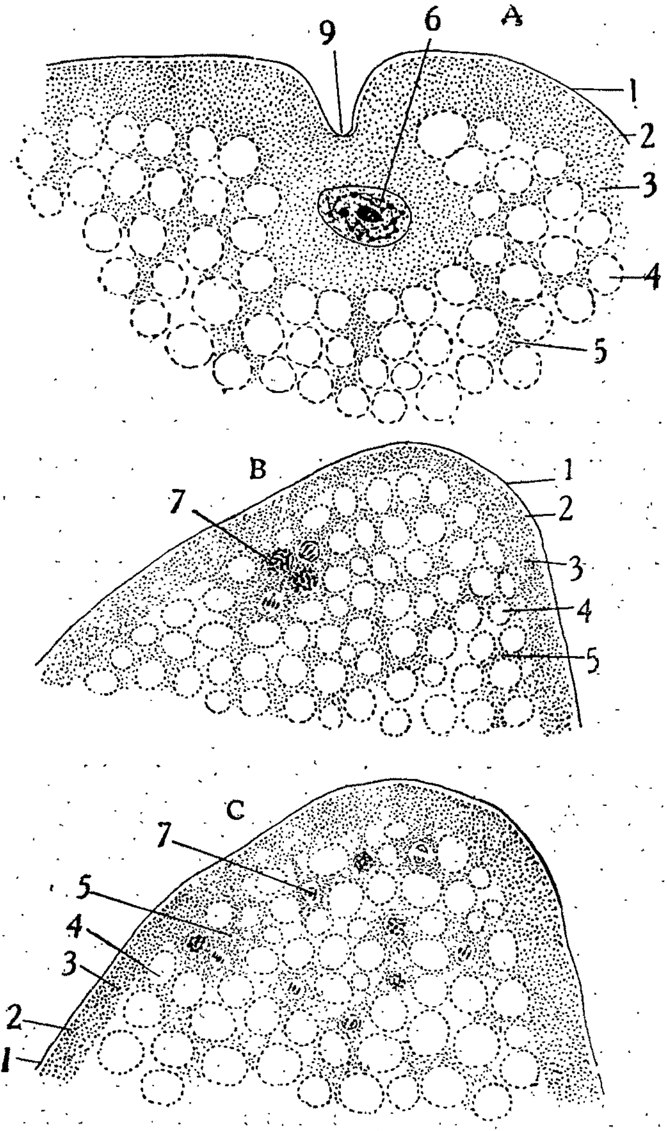


Fig. I. A. L. S. of the egg soon after fertilization anterior part. (x1000).
B. L. S. 15 minutes after oviposition, anterior end. (x450).
C. L. S. one hour after incubation, anterior end. (x450).
1 Chorion, 2 Vitelline membrane, 3 Periplasm,
4 Yolk, 5 Reticuloplasm, 6 Fusion nucleus,
7 Cleavage nuclei, 9 Micropyle.

Brachyrhinus, there is no trace of these bodies in *Mylabris* immediately after oviposition.

The nuclear fragments are spherical bodies surrounded by a dense envelope of cytoplasm. The divisions of the nuclear fragments follow in rapid successions of and in about one hour of incubation, the number of the nuclear bits has increased greatly. These nuclear bits (Fig. I, C, 7) are to begin with confined to the anterior one-fourth of the egg. The cytoplasmic envelop round each nuclear fragment is considerable at this time. While rapid divisions are taking place, the nuclear fragments also move into the reticuloplasm, primarily more rapidly to the posterior and rather somewhat more slowly to the egg periphery.

At the sixth hour of incubation the number of cleavage nuclear fragments (Fig. II, A, 7) has still further increased and greatly exceeds that of *Brachyrhinus* at its ninth hour of incubation. Most of the nuclear fragments have by now travelled back to nearly the middle of the egg. The cytoplasmic envelope round each nuclear fragment is still dense. The appearance of the reticuoplasm now shows signs of changes; the yolk globules are also perceptibly diminishing, apparently due of digestion and absorption and the reticulate appearance of the central mass of the cytoplasm is gradually giving place to a more compact mass.

The nuclear fragments reach the posterior end of the egg in the ninth hour of incubation. (Fig. IV, A, 8) According to Butt (1) at this time the nuclear fragments of *Brachyrhinus* hardly total upto 16-32 stage and still remain largely in the equatorial zone of the egg. In *Mylabris* the nuclear fragments that reach the posterior end of the egg and penetrate the socalled oösome appear first to increase in size and the cytoplasm also seems to condense round each nuclear bit. These nuclear bits represent the socalled germ track determinants. (Fig. IV, A, B, 8) The oösome is irregular as in *Brachyrhinus*, but has relatively conspicuous projections into the yolk. The nuclei which have not penetrated the oösome in the posterior region of the egg but still remain largely within the reticuloplasm become surrounded by radiating strands of cytoplasm. (Fig. II, A, 7) Within nine hours of incubation the entire egg has been traversed by the rapidly dividing and migrating nuclear fragments, which have reached very near the periplasm of the dorsal and ventral sides of the egg but at the anterior end they are still deeper within the reticuloplasm. (Fig. II, A)

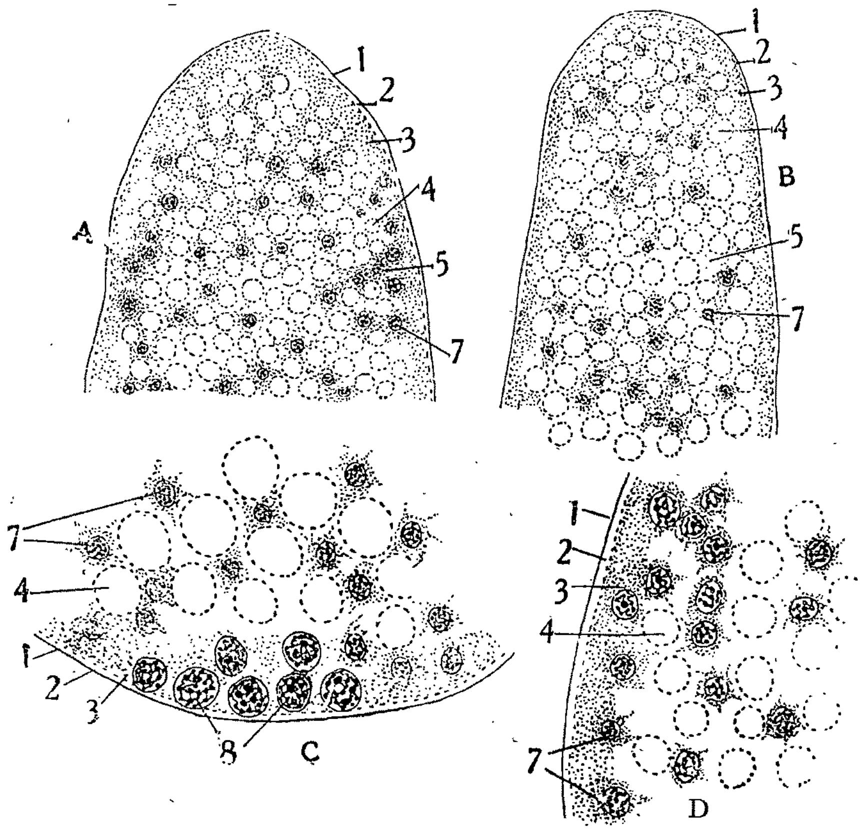


Fig. II. A. L, S. 10 hour incubated egg, anterior part. (x200).
B. L. S. 6 hour incubated egg, anterior part. (x200).
C. L. S. 12 hour incubated egg, posterior part. (x450).
D. L. S. 10 hour incubated egg, middle part. (x450).
1 Chorion, 2 Vitelline membrane, 3 Periplasm, 5 Yolk, 5 Reticuloplasm, 7 Cleavage nuclei, 8 Germ cells.

In the tenth hour of incubation the cleavage nuclear fragments start entering the periplasm in the middle of the egg. (Fig. II, D, 7) This event occurs in *Brachyrhinus* only as late as the thirtieth hour of incubation. Though in *Mylabris* a few fragments have penetrated the periplasm, the great majority of the fragments however lie just beneath the periplasmic envelope of the egg. The cytoplasmic envelope round the nuclear fragments in contact with the inner surface of the periplasm presents delicate thread like projections within the reticuloplasm. Some of the nuclear fragments do not migrate to the peripheral protoplasm but remain behind within the reticuloplasm. At the anterior end of the egg the nuclei are still far away from the periplasm. They seem to have apparently migrated further behind from the position which they occupied at the sixth hour of incubation. At the posterior end of the egg the cytoplasm seems to have diminished cosnspicuously and the socalled germcells show further increase in size and also a distinct backward shift (Fig, IV, A, 8).

At the twelfth hour of incubation the cleavage nuclear fragments in the anterior end of the egg start moving and only reach close to the periplasm. (Fig. III, A, 7) In the equatorial zone of the egg a large number of the nuclear fragments have by now penetrated the periplasm and some have even come to lie just beneath the vitelline membrane (Fig. IV, D, 7).

At the twelfth hour of incubation the socalled germ cells (Fig. II, C, 8) in the posterior region of the egg have shifted further backwards and the majority of them come to lie in close contact with the vitelline membrane. A few of them may even bulge outwards conspicuously. At the anterior end most of the nuclear fragments lie in close contact of the periplasm. (Fig, III, A, 7) In the middle of the egg the penetration of the nuclear fragments into the periplasm is progressing very fast. The cytoplasm condenses more and more round the nuclear fragments which are also compact at this stage.

At the fifteenth hour of incubation the cleavage nuclei have penetrated the periplasm in the anterior end (Fig. III, C, 7) of the egg also. In the equatorial zone of the egg the number of nuclei (Fig. IV, C, 7) in the periplasm has increased further and the outward migration of the cleavage fragments seems almost to have reached the climax. The vast majority of the nuclei in the periplasm are in contact with the vitelline membrane. The indications of a regular arrangement of the nuclear bits are already evident.

In the twentieth hour of incubation the penetration of the nuclear fragments into the periplasm of the anterior end of the egg is almost complete. (Fig. III, D, 7) In the middle of the egg (Fig. III, B, 7) most of the nuclei have become orientated in a

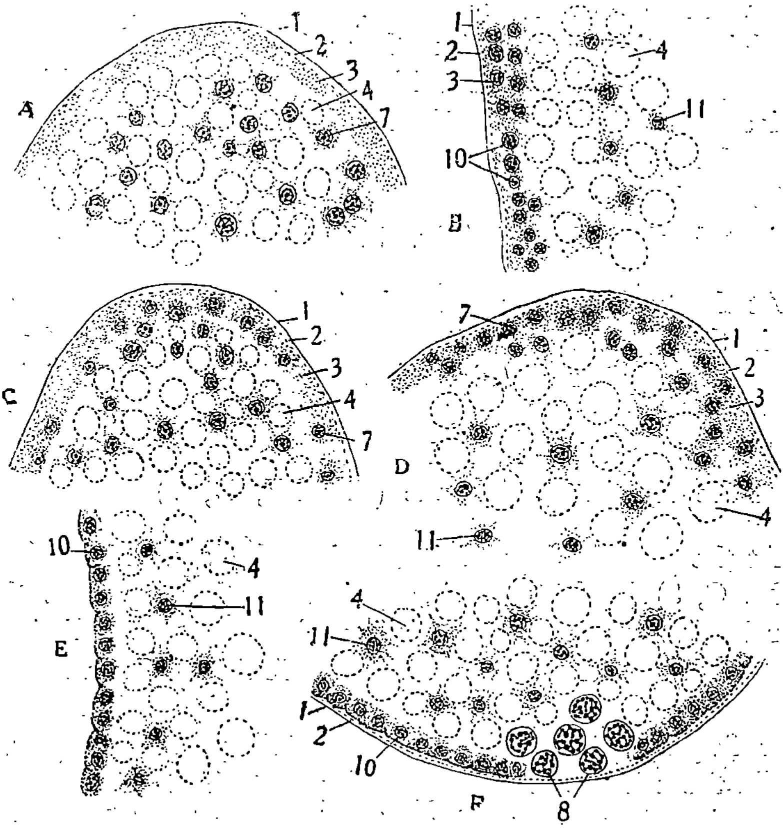


Fig. III. A. Longitudinal section 12 hour anterior end. (x450).
B. L. S. 20 hour middle region. (x450).
C. L. S. 15 hour anterior end. (x450).
D. L. S. 20 hour anterior end. (x450).
E. L. S. 30 hour middle region. (x450).
F. L. S. 30 hour posterior end. (x450).
1 Chorion, 2 Vitelline membrane, 3 Periplasm, 4 Yolk, 7 Cleavage nuclei, 8 Germ cells, 10 Cleavage cells, 11 Yolk cells.

regular layer. Some of the cleavage nuclei, which did not move into the egg periphery but remained behind within the reticuloplasm constitute the socalled vitellophags. (Fig. III, B, D, 11) They have a cytoplasmic envelope with delicate cytoplasmic strands all round.

After twenty-four hours of incubation all the nuclei in the periplasm have arranged themselves more or less regularly in a uniform layer. (Fig. V, C, 10) The cytoplasm now begins to accumulate and condense round each of these nuclear bits. The nuclei also appear to be relatively small and undergo a few rapid divisions. Just beneath the vitelline membrane we have now a regular closely packed multinucleate periplasm everywhere, except near the posterior end of the egg.

II. FORMATION OF THE BLASTODERM

So far the zygote nucleus has undergone rapid and repeated fragmentations and the resulting nuclear fragments have moved to the periphery. These changes have given rise to the formation of an enormous syncitial mass enclosing the yolk, but so far there has been no indication of organization into cells. At the thirtieth hour of incubation the first indications of the division of the peripheral cytoplasm (Fig. III, E, F) become evident on the outside. The outer boundaries of the cell wall are thus the first to become apparent but soon the cytoplasmic constrictions round each of the peripheral layer of nuclear bits progress deeper inwards. Six hours later these constrictions have progressed so far that the boundaries between the adjacent cells are distinct, (Fig. V, B) but even at this stage the inner side shows no distinct cell limits. The inner boundaries of the cell walls are last to appear. At about the forty-eighth hour of incubation the formation of definitive cells of the blastoderm (Fig. V, D, F, 12) is complete and we have almost the complete blastoderm. The blastoderm cells appear in sagittal sections as columnar. Except at the posterior end of the egg where the socalled germ cells (Fig. V, F, 8) are located, the blastoderm is fully organised throughout the entire surface of the egg. The appearance of a definitive blastoderm occurs in different ways in the elongate egg of Coleoptera. The blastoderm is evident in the equatorial zone in *Hydrophilus*, Heider (4, 5, 6), *Doryphora*, Wheeler (13), *Tenebrio*, Saling (12), *Lina*, *Clythra*, *Gastrophysa* and *Agelastica*, Lecaillon (9) and then becomes progressively evident both in front and behind. In the case of *Meloë* Nusbaum (10,11), however describes the formation of the blastoderm as being initiated in the posterior pole of the egg. Hirschler (7, 8) describes the blastoderm of *Donacia* as becoming evident ventrally in the equatorial zone of the egg very much before it spreads over the ventral surface to the anterior and posterior ends and advances laterally over to the dorsum. The last part of the blastoderm to be completed are the polar areas on the dorsum.

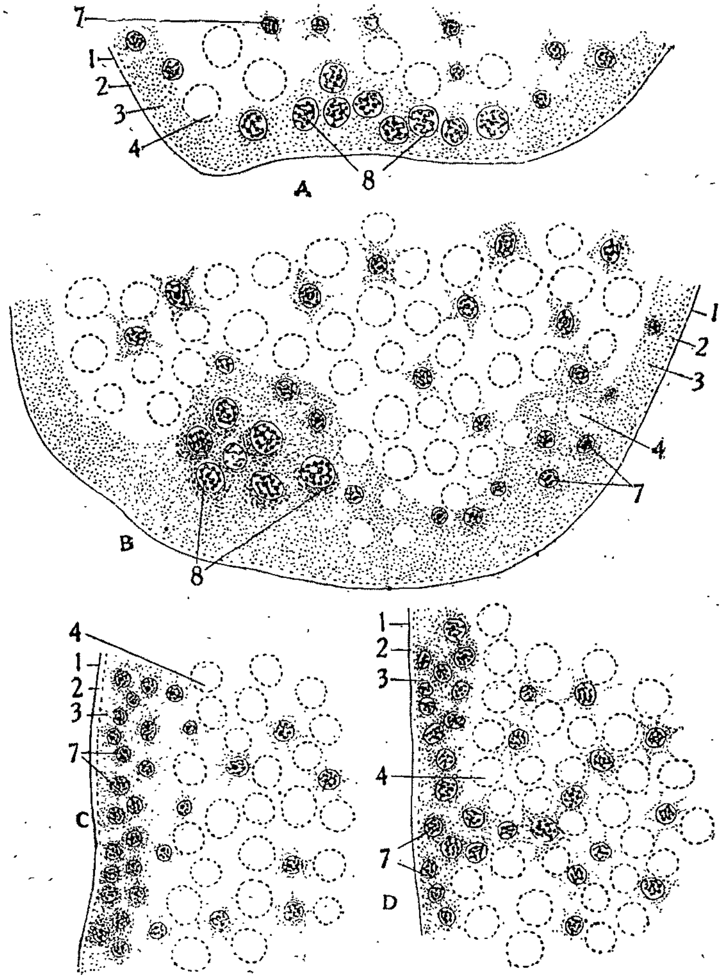


Fig. IV. A. L. S. 10 hour posterior end. (x450).
B. L. S. 9 hour posterior end. (x675).
C. L. S. 15 hour middle region (x450).
D. L. S. 12 hour middle region. (x540).
1 Chorion, 2 Vitelline membrane, 3 Periplasm. 4 Yolk. 7 Cleavage nuclei, 8 Germ cells.

III. THE FORMATION OF THE GERM BAND

After 60 hours of incubation the blastoderm cells in the posteroventral area of the egg become clearly differentiated into a band of larger and deeper cells, which pass gradually into the ordinary blastoderm cells in front. The specialised band of such cells is the germ band. (Fig. V, E, 13) At this stage the germ band occupies a very small portion posteroventrally. At the 68th hour of incubation the germ band (Fig. VI, A, 13) extends forward nearly up to the middle of the egg and also laterally to a certain extent. In the rest of the blastoderm or the extra-embryonal blastoderm the cell now conspicuously flatten out and constitute the serosa. (Fig. VI, A, B, 14) The yolk cells (Fig. VI, A, P, 11) are scattered throughout the central yolk mass. The size and topographical relations of the germ band seem to vary considerably in the order Coleoptera. In *Chrysomela* and *Tenebrio*

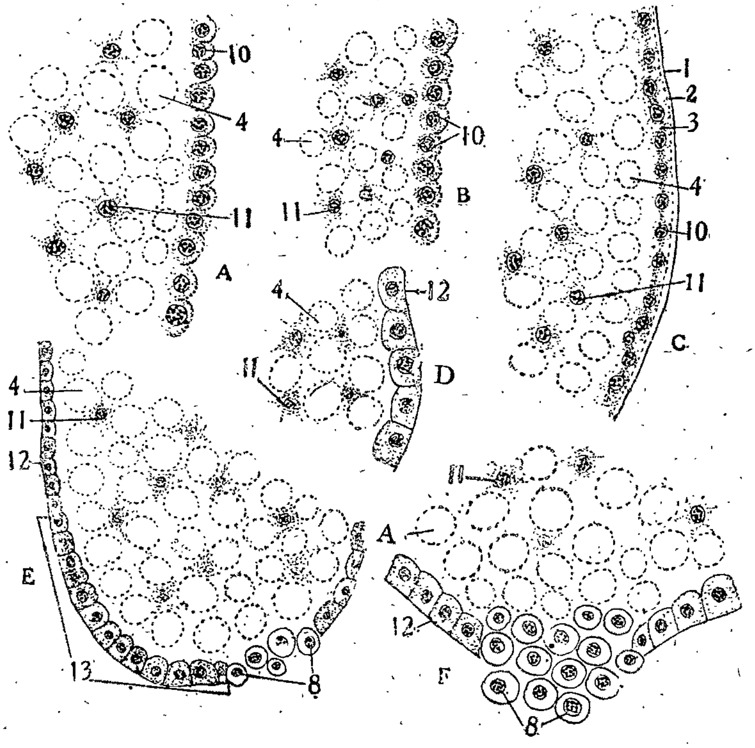


Fig. V. A. L. S. 40 hour middle region. (x540).
B. L. S. 36 hour middle region. (x450).
C. L. S. 24 hour middle region. (x450).
D. L. S. 48 hour portion of blastoderm. (x540).
E. L. S. 60 hour posterior end showing the early differentiation of germ band. (x450).
F. L. S. 48 hour posterior end. (x540).
1 Chorion, 2 vitelline membrane, 3 Periplasm, 4 Yolk, 8 Germ cells, 10 Cleavage cells, 11 Yolk cells, 12 Blastoderm, 13 Germ band.

the germ band is, for example, relatively large. In *Meloë*, Nusbaum (10), *Melolontha*, Graber (3) and *Hydrophilus*, Heider (4, 5, 6) the germ band is, on the other hand, comparatively small and as in *Mylabris pustulata*, confined to only the posterior part of the egg.

IV. The Formation of the Ventral Groove and the Inner Layer

Nearly 72 hours after oviposition the primary dorsal organ (Fig. VI, B, 15) and the ventral groove (Fig. VI, C, D, 16)

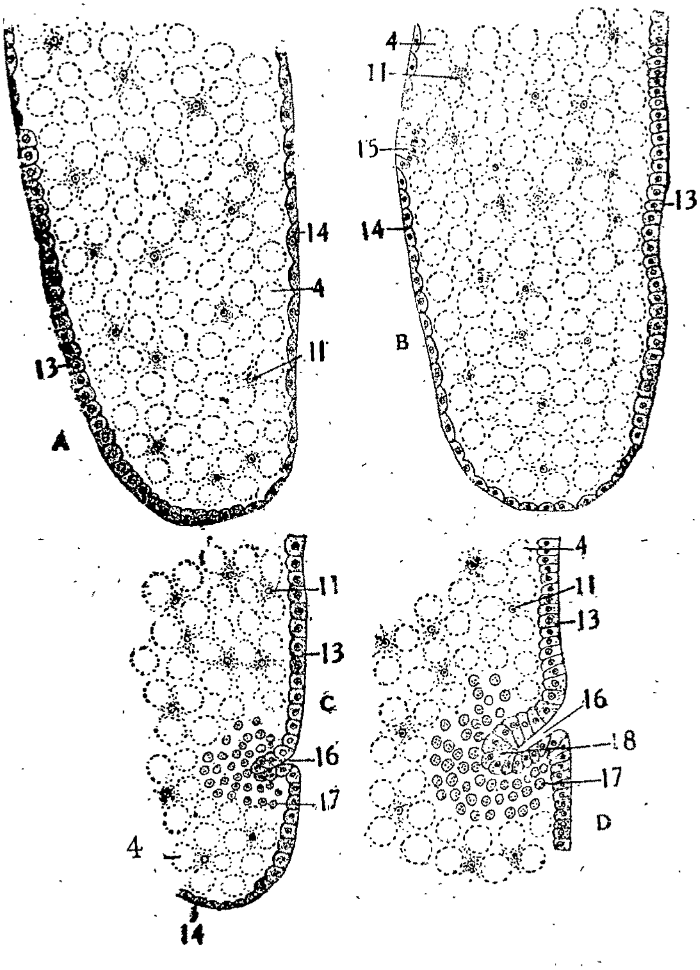


Fig. VI. A. L. S. 68 hour posterior half germ band completed (x300).
B. L. S. 72 hour posterior half, formation of the primary dorsal organ. (x300).
C. L. S. 72 hour posterior end to one side of the median longitudinal line 4 (x450).
D. L. S. 72 hour posterior end in the median longitudinal line. (x450).
4 Yolk, 11 Yolk-cells, 13 Germ band, 14 Serosa, 15 Primary dorsal organ, 16 Gastrular furrow, 17 Proliferating cells, 18 Middle plate.

make their appearance. In transverse section of the egg fixed at the 72nd hour of incubation and passing through the anterior region of the germ band (Fig. VII, A, B) there is no indication of any groove in the median ventral line. On the dorsal side opposite the middle of the germ band the blastoderm cells modify into a small cluster of cells, which project conspicuously into the yolk. The outer ends of these cells stain rather more deeply than the somewhat obscure inner ends. The structure is the so-called primary dorsal organ (Fig. VII, A, 15) and is confined to about the middle of the egg just opposite the anterior end of the germ band. It is short. The development of the primary dorsal organ by the invagination of the extra-embryonal blastoderm on the dorsal side has been carefully described in several species of Coleoptera, including *Meloë*. While in *Mylabris* the dorsal organ is rather small, in some other species like *Tenebrio molitor*, Saling (12) has described it as attaining considerable proportions, reaching to nearly one-third of the length of the egg but located in the middle. In *Brachyrhinus* the primary dorsal organ is described by Butt (1) to become differentiated relatively very soon after the appearance of the blastoderm, there is no indication of it until after the formation of the germ band. It also persists upto the 72nd hour stage of development.

In transverse section a little behind the anterior end of the germ band we find a shallow trough-like invagination of the germ band. This represents the formation of the middle plate (Fig. VII, C, 18) and the portions on either sides of the trough-like mass constitute the lateral plates. (Fig. VII, B, C, 19) In the sections passing through the middle region of the egg the germ band shows a distinct invagination with a shallow median groove, (Fig. VII, B, 16) but no cells seem to be proliferating from the middle plate. In sections a little behind the middle part of the egg the median groove is still deeper and the cells are seen proliferating (Fig. VII, E, 17) actively from the middle plate. The number of such proliferating cells is however not very great. In the posterior-most region of the germ band the median groove is deepest and the proliferation of cells is also very intense. (Fig. VII, D) It is thus evident that the median ventral groove appears first in the posterior region of the germ band

and gradually extends forward. This is particularly seen in sagittal sections of the egg, in which the median ventral groove is found only in the posterior part. (Fig. VI, C, D, 16) The proliferation of cells also appears to commence first from the posterior region and then progressively extend forward. The germ band in the anterior part shows a shallow trough-like invagination.

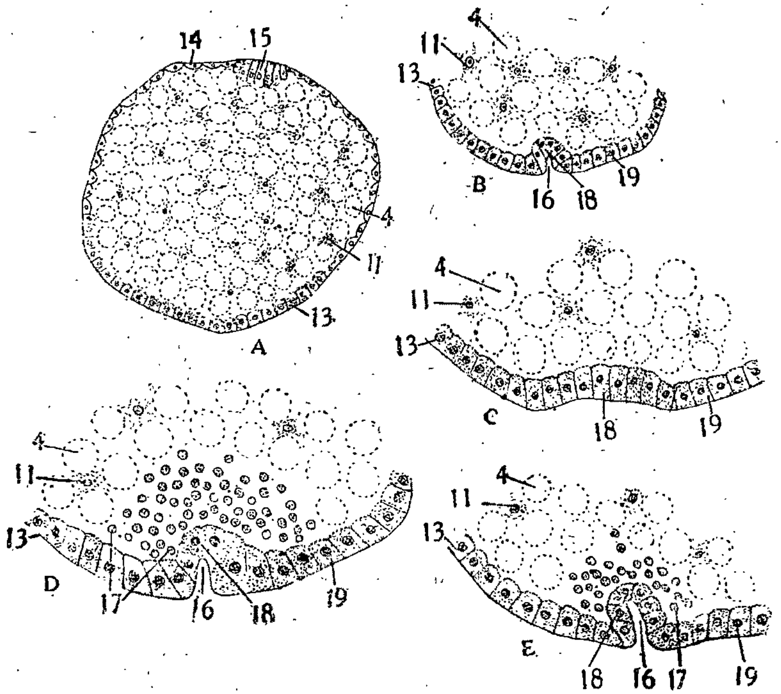


Fig. VII. A. T. S. 72 hour anterior region of the germ band. (x100).
B. T. S. 72 hour passing through slightly beyond the middle of the germ band. (x675).
C. T. S. 72 hour middle of the germ band. (x450).
D. T. S. 72 hour posterior most end of the germ band. (x450).
E. T. S. 72 hour slightly in front of the posterior most region of the germ band. (x450).
4 yolk, 11 Yolk cells, 13 Germ band, 14 Serosa, 15 Primary dorsal organ, 16 Gastrular furrow, 17 Proliferating cells, 18 Middle plate, 19 Lateral plate.

Summary of Development at Different Hours of Incubation

Incubation period	State of development.
Oviposition.	Fertilization.
15-30 minutes.	Cleavage begins.
1 hour.	Number of cleavage nuclei increased but remain only in the anterior end.

6 hours	Cleavage nuclear fragments move upto the middle of the egg.
9 "	Cleavage nuclear fragments enter the oösome.
10 "	A few nuclear fragments enter the periplasm in the middle zone, in the anterior end they are still deeper in the reticuloplasm, oösome is reduced and the nuclei entering it are enlarged in size.
12 "	The number in the middle region increased, the socalled germ cells are in contact with the vitelline membrane, the nuclei in the anterior end are still deeper.
15 "	Cleavage nuclei enter in the periplasm in the anterior end, in the middle region more of the cleavage nuclei enter the periplasm.
20 "	More nuclei enter the periplasm in the anterior end, in the middle region they start rearranging in a line.
24 "	Cleavage nuclei nearly arranged in a line throughout except in the posterior end where the socalled germ cells are located.
30 "	The periplasm condenses round the nuclear bits and the outer cell walls appear.
36 "	The outer cell walls become more prominent, the constrictions become more pronounced.
40 "	The lateral walls become prominent.
48 "	The lateral and inner walls fully developed and the blastoderm completed, at the posterior end the socalled germ cells are in the form of a plug.
60 "	The germ band makes its first appearance at the postero-ventral end.
68 "	The germ band completed extending nearly upto the middle of the egg.
72 "	Gastrulation begins in the form of a furrow at the posterior end of the germ band.

REFERENCES

1. BUTT, F. M. 1936. The early embryological development of the parthenogenetic alfa-alfa snout beetle, *Brachyrhinus ligustici*, L. *Ann. entom. Soc. America*, **29** : 1-13.
2. DEOBHAKTA, S. R. 1953. Preliminary notes on the early embryonic development of *Mylabris pustulata* Thunb. (Coleoptera), *Agra Univ. J. Res.* (*Sci.*), **2** : 125-134.
3. GRABER, V. 1888. Uber die primäre Segmentirung des Keimstreifs der Insekten, *Morph. Jahrb.* **14** : 345-368.
4. HEIDER, K. 1885. Über die Anlage der Keimblätter von *Hydrophilus piceus*, L. *Abhandl. d. kaiserl. preuss*, *Akad. Wiss. Berlin*, pp. 1-47.
5. HEIDER, K. 1889. Die Embryonalentwicklung von *Hydrophilus piceus*, L. *Jena*. pp. 1-98.
6. HEIDER, K. 1890. Erwiederung auf die Bemerkungen v. Grabers zu meiner Abhandlung Über die embryonal entwicklung von *Hydrophilus piceus*, L. *Zool. Anz.*, **13** : 428-430.
7. HIRSCHLER, J. 1907. Über leberartige Mitteldarmdrüsen und ihre embryonale Entwicklung bei *Donacia* (Celeoptera), *Zool. Anz.*, **31** : 766-770.
8. HIRSCHLER, J. 1909. Die Embryonalentwicklung von *Donacia crassipes*, L. *Zeit. wiss. Zool.*, **92** : 627-744.
9. LECAILLON, H. 1898. Recherches sur l' oeuf et sur le development embryonnaire de quelques Chrysomelides., Paris.
10. NUSBAUM, J. 1889. Die Entwicklung der Keimblätter bei *Meloe proscarabaeus* Marsham. *Biol. Centralb.*, **8** : 499-552.
11. NUSBAUM, J. 1890. Studya nad morfologija zweierzat. Przyczynek do embryologii maika (*Meloe proscarabaeus*, Marsham) (In Polish) (Studies in morphology etc. The embryology of *Meloe*, etc.) *Kosmos*, Lemberg, **15** : 17-47.
12. SALING, T. 1914. Zur Kenntnis der Entwicklung und des Keimstreifens von *Tenebrio molitor*, L. *Z. wiss. Zool.*, **86** : 238-303.
13. WHEELER, W. M. 1890. The embryology of *Blatta germanica* and *Doryphora decemlineata*, *J. morphol.*, **3** : 291-386.

Erratum : For *desert locust* on p. 125, vol. 2, part, I, Jan. 1953, line 9 from top in paragraph I, read *migratory locust* (Part I. of this paper).—*Editor.*

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

PART III.—ON A COLLECTION OF DERMAPTERA

By H. N. BAIJAL, M. Sc. and SANTOKH SINGH, M. Sc.,
Research Associates, School of Entomology, St. John's College, Agra.

The type specimens of the new forms described here are deposited in the collections of the Zoological Survey of India, Calcutta. We thank Prof. Dr. Mani for placing this interesting collection at our disposal and for guidance.

Family PYGIDICRANIDAE

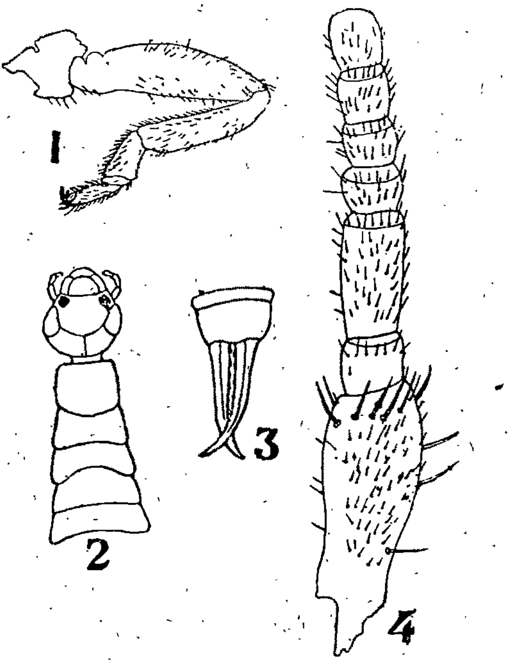
Subfamily Diplatyinae

Diplatys himalayanus, sp. nov.

Male.—Entirely apterous. Body glabrous, small and slender. Head small, smooth, tumid between the eyes and somewhat depressed posteriorly and the two parts are separated by a distinct suture; posterior margin truncate; shape of head as in fig. 2. Antennae with 24 segments, almost cylindrical as in fig. 4; first segment long, stout at apex, second segment short, third segment longer, fourth segment about half as long as the third segment, fifth segment a little longer; the rest of the antennal segments gradually lengthened. Pronotum small, a little longer than broad, narrower than head, slightly wider posteriorly than anteriorly, sides straight, almost rectangular as in fig. 2. Meso—and metanotum smooth, shape as in fig. 2. Legs short and moderately stout, first and third tarsal segments about equally long as in fig. 1; second tarsal segment very small: Abdomen slender, cylindrical, the segments distinctly separated, last dorsal segment truncate; penultimate ventral segment rounded, covering the terminal segment; pygidium not visible. Forceps slender, quite straight and unarmed and gradually tapering and slightly curved near the very tip as in fig. 3. Length of body 8 mm. Length of forceps 3 mm.

---

*Contribution No. 49 from the School of Entomology, published with the permission of the Professor of Zoology & Entomology.



Diplatys himalayanus, Male sp. nov. 1. Fore leg. 2. Head, thorax and base of abdomen. 3. Forceps and last dorsal segment. 4. Antenna.

Holotype male, *paratype* males in spirit. Coll. H. N. Baijal, Loc. Naranikarkana, 5500 ft. Jeolikote, Nainital District September 19, 1952.

This is the first record of wholly apterous species of the genus *Diplatys* Serv[1] from India. This species is readily distinguished from all the other Indian species by its apterous condition.

Family Labiidae

Subfamily Labiinae

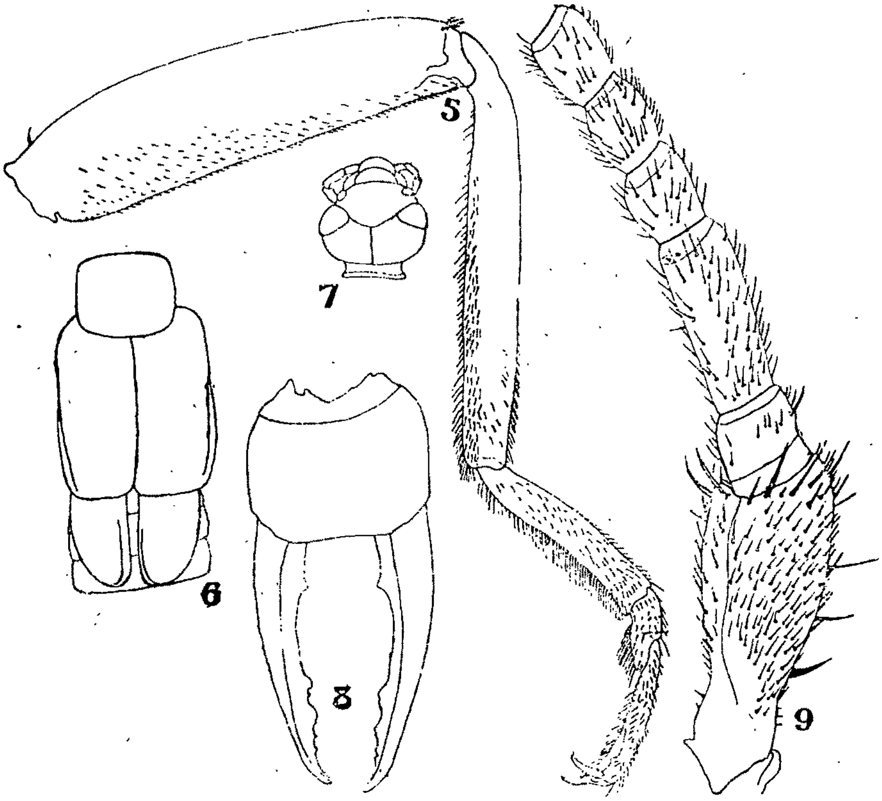
Spongiphora nainitalensis, sp. nov.

Male.—Large, reddish-brown. Head brown and rugulose; eyes prominent, all the sutures complete, shape as in fig. 7. Antennae with 20 segments, brown, the segments cylindrical;

---

[1] Serville. 1931. *Ann. Sci. Nat.*, 22 : 33; Burr, 1910. *Fauna Brit. India*, Dermaptera, p. 38.

third antennal segment long, fourth and fifth segments short as in fig. 9. Pronotum dark brown, somewhat rectangular, prozona tumid and metazona slightly depressed as in fig. 6. Elytra larger than pronotum, transverse posteriorly, with a keel on costal margin as in fig. 6. Wings fig. 6, well developed, with dark brownish spot. Legs fig. 5, yellow, slender, with first tarsal segment one-and one-third the third segment. Abdomen dark brown, apex narrower and base somewhat swollen, last dorsal segment quadrate; penultimate ventral segment triangular and truncate apically; pygidium hidden. Forceps with branches stout, long, with a large tooth near the base and 4 obscure obtuse teeth on each side on the inner margin near the apex as in fig. 8.



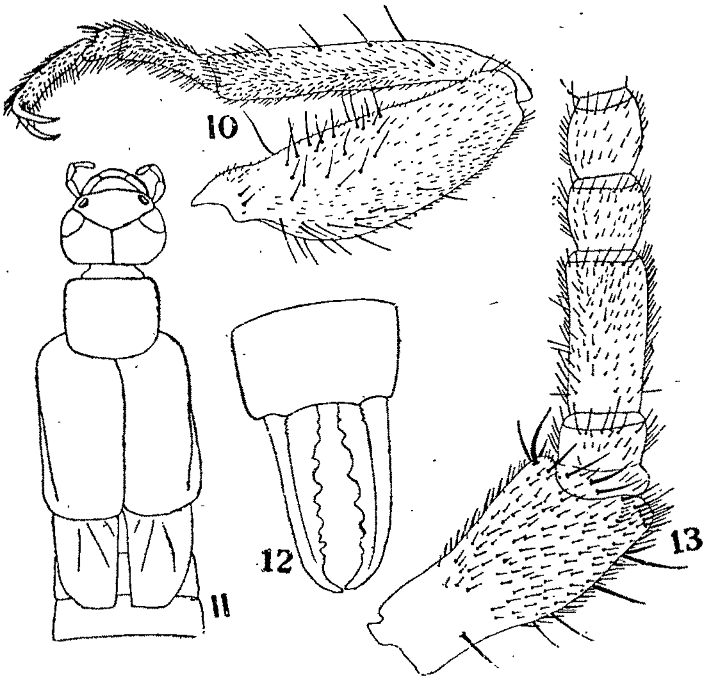
Spongiphora nainitalensis, sp. nov. Male 5. Fore leg 6. Thorax and base of abdomen 7. Head 8. Forceps. and last dorsal segment. 9. Antenna.

Holotype male. Coll. H. N. Baijal, Naranikarkana, 5500ft. Jeolikote, Nainital District; September 19, 1952.

This species can be readily distinguished from the related *Spongiphora lutea* Borm[2]. by the antennal segment, elytra longer than pronotum, well developed wing, the first tarsal segment longer than third and lastly by the differently organised forceps.

Erotesis jeolikotensis, sp. nov.

Female.—Dark brown, large. Head brown, finely rugose, tumid between the eyes, sutures well developed, shape as in fig. 11. Antennae with 30 segments, brownish, slender, cylindrical; third antennal segment long, fourth and fifth segments shorter; the latter a little longer than fourth; the rest of the antennal segments gradually elongate as in fig. 13. Pronotum rugose, prozona somewhat tumid, metazona depressed, anterior margin truncate, posterior margin broadly rounded, side angled as in fig. 11. Elytra finely rugose, light brown, with a keel on costal margin as in fig. 11. Legs fig. 10, yellow, stout, with first and third tarsal segments almost equal. Abdomen brown, cylindrical, penulti-



Erotesis jolikotensis, sp. nov. Male 10. Fore leg 11. Head, thorax and base of abdomen. 12. Forceps and last dorsal segment. 13. Antenna.

---

[2] Borman, 1894. *Ann. Mus. civ. Gen.*, (2) **40** : 380; Burr, 1910. *Fauna Brit. India*, Dermaptera, p. 112.

mate ventral segment rounded, last dorsal segment transverse. Pygidium invisible. Forceps long, dentate as in fig. 13. Length of body 18 mm. Length of forceps 7 mm.

Holotype female, Coll. H. N. Baijal, Naranikarkana, Jeolikote, 5500 ft. Nainital District. September 19, 1952.

This species is distinguished from the only other known Indian species *Eriotesis decipiens* Kirby[3] by the following characters: Antennae with 30 segments, pronotum without dusky median band and by its forceps.

Family FORFICULIDAE

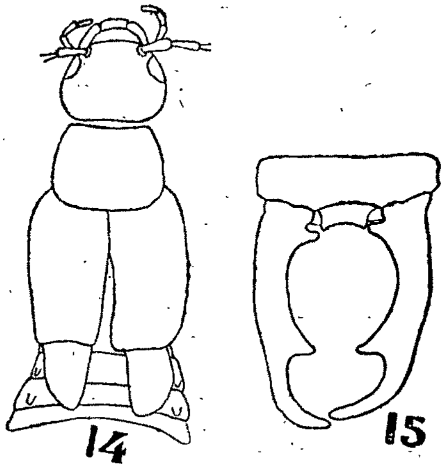
Subfamily Anechurinae

Homotages feae (Bormans)

1888. *Anechura feae*, BORMANS, *Ann. Mus. civ. Gen.*, (2) **4** : 445.
1909. *Homotages feae*, BURR, *Deutsch. ent. Z.* , p. 327, fig. 7.
1910. *Homotages feae*, BURR, *Fauna Brit. India*, Dermaptera, p. 156, fig. 12, 101.

We refer to this species a series of males and females taken on Chakrata Range, 8000 ft. Garhwal Himalayas, Coll. R. S. Mathur and H. N. Baijal, 22-ix-1953.

The specimens before us agree well with the description of the species, but in 2 males (fig. 14, 15) the posterior tooth of the forceps is strong, but has only one basal tooth.



Homotages feae, Bormans Male. 14. Head, thorax and base of abdomen 15. Forceps and last dorsal segment.

---

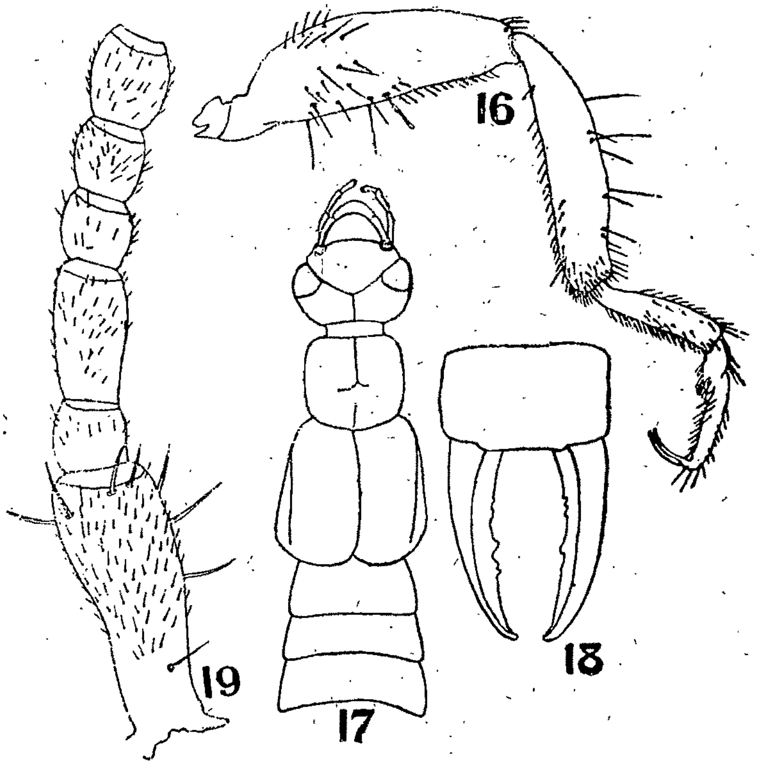
[3] KIRBY, 1891. *J. Linn. Soc. London*, (Zool.) **23** : 511; BURR, 1910. *Fauna Brit. India*, Dermaptera, p. 114.

The species was originally known from the Darjiling Himalayas, Kuamon Himalayas, Nepal, Nainital and Tenasserim.

Subfamily Forficulinae

Elaunon nainitalensis, sp. nov.

Male.—Yellowish-brown, medium-size. Head brown, eyes prominent, with the space between tumid, head depressed posteriorly, general shape as in fig. 17. Antennae with 27 segments, yellow, third antennal segment longer than the rest, fourth and fifth segments shorter as in fig. 19. Pronotum rugose, brown, sides parallel, posterior margin gently rounded as in fig. 17. Elytra larger than pronotum, with keel at costal margin, rugose, general shape as in fig. 17. Wing not visible. Legs pale yellowish-brown, with the first tarsal segment very slightly longer than third as in fig. 16. Abdomen brown, cylindrical, last dorsal segment quadrate, penultimate ventral segment triangular, trun-



Elaunon nainitalensis, Male sp. nov. 16. Fore leg 17. Head, thorax and base of abdomen 18. Forceps and last dorsal segment.

cate apically, covering the last segment. Forceps stout and long, with a pair of minute tooth in the middle, more than 3 small teeth on each side of the inner margin as in fig. 18.

Holotype male Coll. H. N. Baijal, Naranikarkana, 5500 ft. Jeolikote, Nainital District, September, 19, 1954.

This species is separated from the only other known Indian species *E. bipartitus* Kirby[4] by its fourth antennal segment shorter than third, sides of pronotum not flattened, pygidium invisible, forceps with base not dilated to form a tooth-like broad triangular projection.

---

[4] KIRBY, 1891. *J. Linn. Soc. London* (Zool.) **23** : 526; BURR, 1910. *Fauna Brit. India*, Dermaptera, 163, fig. 53, 102.

THE BIONOMICS OF THE MIMUSOPS GALL THRIPS, *ARRHENOTHRIPS RAMAKRISHNAE* HOOD

By T. N. ANANTHAKRISHNAN, B. Sc. (Hons.), F. Z. S., F. R. E. S.,
Lecturer in Zoology, Loyola College, Madras.

INTRODUCTION

As early as 1916 Ramakrishna observed the leaf gall formation in the common shade and garden tree, *Mimusops elengi*, and the causative agent was subsequently described by Hood (3) as *Arrhenothrips ramakrishnae.* Bagnall (1) identified the same from a lot sent from Coimbatore as *Mesothrips ramakrishnae.* In 1920 Karny (4) gave reasons for retaining it under the genus *Arrhenothrips* Hood. This species has hitherto been recorded from all over South India; it is strictly confined to India. Further, *Arrhenothrips* is known to attack only mimusops plants and cause leaf galls. Even though capable of quick flight, it does not seem to attack nearby plants. The author recently came across a mimusops tree very badly attacked by this thrips and most of its leaves galled. This provided excellent material for study and an examination of a very large number of galls revealed the presence of numerous adults eggs, larvae and pupae. So far no attempts have been made to describe the immature stages of this species. This paper therefore aims at bringing together all available details and the life-history stages of this interesting thrips.

DAMAGE

In general the effects of the attack of *Arrhenothrips* are far-reaching, leading to complete gall formation of the leaves and twisting and curling of the shoots, and ultimately leaf fall (Figs. 13, 14). Mani (6) described the gall as "leaf folded on the upper side, crumpled, twisted and thickened irregularly; tissue differentiation absent." All the damaged leaves present numerous, irregular yellowish mottled areas with total absence of chlorophyll.

A badly infested plant can immediately be recognized out by the clusters of deformed, folded and wrinkled leaves.

DESCRIPTION OF LARVAL STAGES

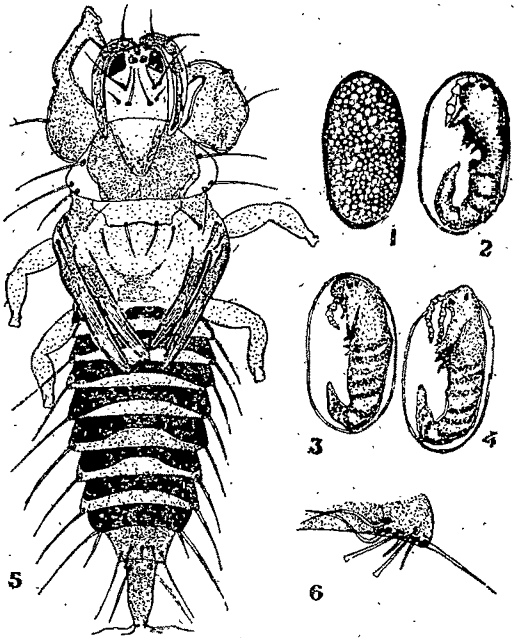
Brief descriptions have been given with illustrations of the egg; two subsequent stages showing body differentiation within egg; the first instar larva emerging from the egg; first instar larva; two subsequent larval moults; prepupa; pupae 1, 2, and 3. It is interesting to note that three distinctly different grades of pupa can be recognized and can be identified as follows :—

Pupa 1. Antennae just thrown back, short; wing pads rudimentary; ocelli undeveloped.

Pupa 2. Antennae thrown well back, wing pads elongate. Ocelli developed. Wing pad margins not thickened and fringes undeveloped; feeble chitinisation of the body.

Pupa 3. Wing pads with thickened and cornified margins and with fringes developed (seen as frayed structures). Chitinisation of the body far advanced.

The egg (fig. 1). The eggs are oval, elongate, whitish, transluscent, measuring on an average 0.448 mm. long and 0.182 mm thick. The size of the egg ranges from 0.434 mm long and



Arrhenothrips ramakrishnae. 1. Egg, 2-4 stages of embryo, 5. pupa (3), 6. chaetotaxy of posterolateral part of abdominal segment of pupa (3).

0.196 mm thick to 0.462 mm long and 0.238 mm thick. One end of the egg is slightly narrower than the other and it is through this end that the larva emerges. The egg-laying capacity of the females was studied by leaving half a dozen males and half a dozen females in a 6″ × 1″ tube, the mouth of which was covered by a fine muslin. The average egg-laying capacity is 8.

In the figs. 2 and 3 the body of the embryo is clearly distinguishable, along with a well demarcated head, bearing a pair of dark red pigmented eyes and rudimentary segmented antennae, directed downwards. The embryo lies along one side pushing the yolk. In fig. 4 the egg undergoes a crack and the narrower end transversely, so as to make possible the emergence of the first instar larva.

First instar larva. (fig. 8) Pale yellow, with a slight brownish tinge. Eyes dark red. Antennae pale yellow; joints 2 and 3 extremely pale, tending to white; ninth abdominal segment, tube, pronotum and base of legs showing sclerotisation.

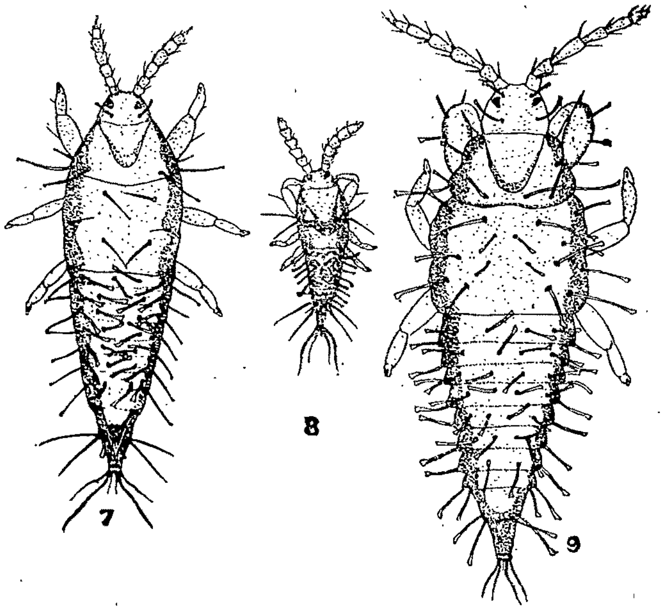
Total body length 0.518 mm; head broader than long; mouth-cone very long, broadly rounded, reaching well beyond the base of the pronotum. Maxillary palp well developed, 2-jointed, basal joint short, stout and 1/4 the length of the narrower distal joint. Head and mouth-cone length 0.172 mm. Total antennal length 0.154 mm. Antenna 7-jointed, the antennal joints are shorter and stouter than in subsequent instars; joints 3 and 4 largest. Sense cones feebly developed—(3) 0-1 (4) 0-1; pronotum length 98 micra, width 126 micra. Abdomen gradually narrowing towards tube; abdominal bristles well developed. All body bristles transparent yellow. Tube 56 micra; anal bristles 42 micra.

Larva after first moult (Fig. 7.). Colour grey-yellow with more prominent marks of scelerotisation, especially at bases of legs, sides of pronotum, abdominal segments and tube. Antennae essentially liked the first instar. Eyes dark red.

Total body length 1.106 mms. Head almost as long as broad; length of head 98 micra head and mouthcone length

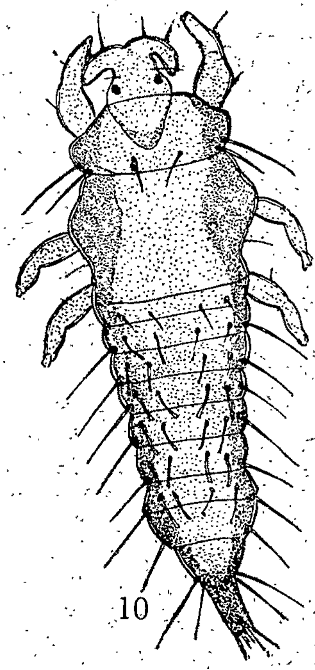
0.196 mms. Postocular and anteocular bristles well developed and knobbed. Antennal length 0.210 mm; sense cone formula (3) 0-1; (4) 1-i; (5) 0-1; (6) 0-1. Pronotum widest at base, broader than long; length of pronotum 140 micra, breadth 280 micra; mouth-cone shorter and reaching slightly away from the base of the pronotum; anal bristles 84 micra; tube 70 micra.

Larva after second moult (fig. 9). Colour dark yellow; pronotal plates better sclerotised than in the previous stage; body bristles well developed, long, distinctly knobbed and transparent. Antennae much longer and shape of joints almost like that of the adult, the individual joints being longer, especially 3 and 4; joint 2 cylindrical; 3 and 4 elongate, narrow at base and wider at apex, longer than wide; 5 and 6 similar but shorter and almost as long as thick. Total body length 1.28 mm; head length 0.15 mm; head and mouth-cone length 0.28 mm; total antennal length 0.32 mm; length of third antennal joint 84 micra; prothorax length 0.210 mm width 0.322 mm tube 112 micra; anal bristles 112 micra.



Arrhenothrips ramakrishnae. 7. Larva after first moult, 8. First instar larva, 9. Larva after second moult.

Prepupa (fig. 10). Colour golden-yellow; antennae and sides of legs pale yellow with whitish patches. Head small; eyes black; antennae in the form of two short stumps laterally directed. Body not much sclerotised. Total body length 1.470 mm; Antennal length 0.168 mm; head length 0.168 mm; prothorax length 0.252 mm width 0.392 mm; tube length 0.168 mm.

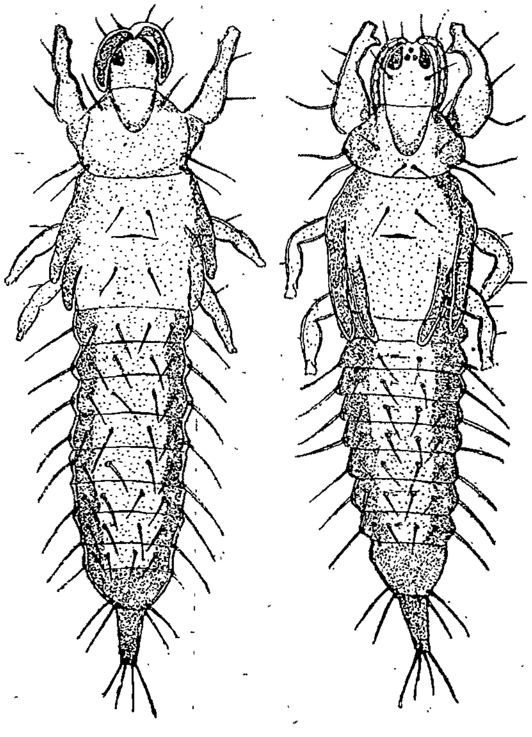


Arrhenothrips ramakrishnae. 10. Prepupa.

Pupa I (fig. 11). Colour light yellow, but with more of the brownish pigment than the prepupa. Eyes large, with dark red pigment; ocelli not developed. Antennae directed backwards and almost closely apposed to the cheeks, short and stopping short of just the base of the head. Antennal segmentation feeble;

wing pads just developing, rudimentary and jutting out of the pterothorax; fore femora slightly enlarged; tarsal tooth very small. Total body length 2.17 mm; head and mouth-cone length 0.518 mm; total antennal length 0.238 mm; head length 0.172 mm; pronotum length 0.280 mm; tube length 0.168 mm; length of wing pads 0.350 mm.

Pupa 2 (fig. 12). Colour light brown, all over with yellowish pigment. Middle of head, thorax of a darker shade. Eyes dark



Arrhenothrips ramakrishnae. 12-13. Pupae 1 and 2.

with little red pigment. Ocelli distinct, triangular, with dark red pigment; head distinctly longer than broad with well developed postocular bristles. Antennae thrown well back over prothorax, distinctly jointed. Fore femora much enlarged and tarsal tooth well developed, stout, blunt and triangular. Wing pads long and fully developed, reaching beyond the third abdominal segment. Wing margins not thickened and cornified and wing fringes not developed. Sclerotization of abdominal segments very feeble. Total body length 2.212 mm; head and mouth-cone length 0.518 mm; total antennal length 0.378 mm; head length 0.280 mm; tube length 0.210 mm; length of wing pads 0.448 mm.

Pupa 3(fig. 5). General body colouration yellowish-brown; pronotum mostly dark brown except for the postero-lateral margins. Pterothorax brown at middle with yellow all round; eyes black, with slight traces of black pigment at border. Ocelli with dark red pigment. Abdominal segments 1 to 8 dark brown, being distinctly chitinised to form plates. Segments 9 and tube not much sclerotised. Head about 1.5 times as long as broad. Fore femora extremely broad, much broader than head; tarsal tooth quite long, almost pointed as in the adult. Tibial tubercles distinct. Three sub-basal bristles of wings distinctly seen. Wing pad margins thickened and cornified, with well developed fringes inside seen as frayed structures. Total body length 2.230 mm; total antennal length 0.392 mm; head length 0.280 mm; width 0.196 mm; prothorax length 0.308 mm; width 0.518 mm; tube length 0.210 mm; length of wing pads 0.672 mm; tarsal tooth length 42 micra; width 28 micra.

Adult female.—"Colour dark blackish-brown with head, fore femora, middle and hind tarsi and interstices of pterothoracic plates, paler; fore legs with tibiae, tarsi and apices of femora yellow, the tibiae darkened with grey or brown particularly along outer surface; antennae with segment 1 and inner basal half of segment 2 blackish-brown, the remainder clear lemon-yellow and of deeper tint towards apex; head 1.65 times as long as wide; cheeks nearly straight and slightly converging to base. Postocular bristles shorter than eyes, dilated at apex. Ocelli equidistant, anterior ocellus overhanging, opposite anterior margin of eyes. Antennae about 1.6 times as long as head, prothorax equal in length to head and nearly 1.7 times as wide as long. All usual bristles present, blunt. Wings yellowish at base. Fore wings with three sub-basal bristles. Fore femora about 1.5 times as long as and distinctly wider than head. Fore tibiae produced and subangulate at inner surface of apex; fore tarsi with a stout and nearly straight tooth; tube about 0.8 as long as head. Total body length about 2.5 mms; *Male.*—total length about 2 mm; colour essentially as in female; head 1.5 times as long as wide, cheeks distinctly wider. Fore femora equal in length to and distinctly narrower than head. Prothorax only 3/4 as long as head. Tarsal tooth shorter than width of tarsus."

HABITS OF THE ADULT

In order to observe the general habits of the adults a number of specimens were left in tubes 6″ × 1″, with a healthy leaf in each tube. The mouth of the tube was covered with muslin. There was a general tendency of the adults to congregate around the tips of the leaves and also close to the midrib. A day after they were left, the surface of the leaf at places where they congregate, was found irregularly moistened and these areas subsequently showed slightly darkened patches as a result of the feeding of the adults. Copulation was free, the smaller males chasing the females and mounting on their back, having a firm hold with the fore legs clasped round the thorax. The posterior part of the abdomen was violently moving in an attempt to bring the tip of the abdomen under that of the female. A slight disturbance made the pair move in the interlocked position and the movement was continued for full three minutes, when they moved along one tip of the leaf to the other along the outer and inner sides, after which they separated. Within the tube the adults, especially the females, exhibited well developed powers of flight, often flying from one end of the tube to the other.

Repeated experiments to rear the early stages, especially up to the final instar larva, resulted in failure because they die under laboratory conditions, probably due to excessive heat. Here and there a few individuals moulted but this was insufficient for establishing a general period for the life-history. It was however observed that oviposition took place six to seven days after copulation, since copulation was observed on 18-3-54 in one tube and on 20-3-54 in another and eggs were observed on the leaves on 24-3-54 and 27-3-54 respectively.

Table showing differentiation of larvae, pupae and adults on basis of length of body, femoral width, length of 9th abdominal segment, tube and wings.

Stages.	Body length in mm.	Femoral width in micra.	Length of 9abd seg. in micra.	Length of tube in micra.	Length of wing pads in mm.
First	0.172	28	28	56	—
Second	1.106	42	50	70	—
Third	1.288	70	70	98	—
Prepupa	1.470	70	70	112	—
Pupa 1	2.17	84	84	168	0.350
Pupa 2	2.212	140	140	210	0.448
Pupa 3	2.23	154	140	210	0.672
Adult female	2.5	252	140	238	1.148
Adult male	2	196	96	196	1.190

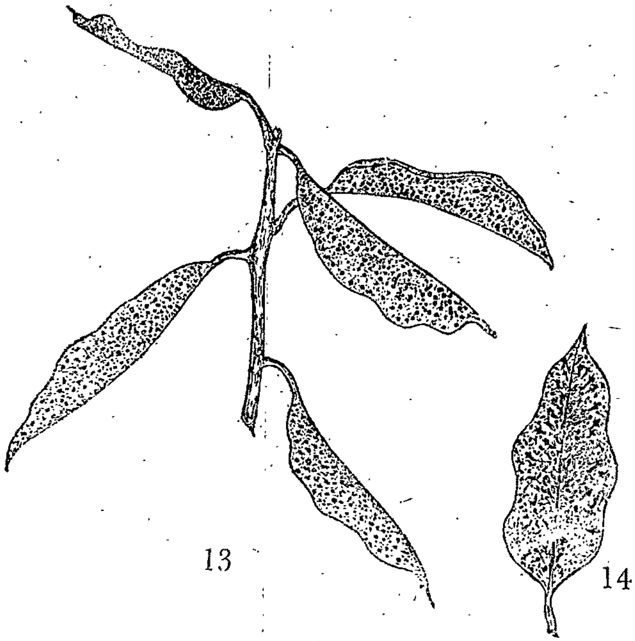
Sex ratio.—The males and females were isolated and counts were taken to establish a general ratio of the males and females, as shown in the table below. The females always predominate the males.

Gall no.	Total No. of adults.	Males.	Females.	Ratio.
1	63	23	39	4:7
2	59	17	42	4:5
3	76	30	46	2:3
4	37	15	22	5:7

The sex ratio is therefore roughly 2 : 3.

GALL ASSOCIATIONS

Ramakrishna has recorded the association of *Rhyncothrips vichitravarna* with *Arrhenothrips* in fairly good numbers and in addition few forms of *Androthripes flavipes* also. In more than a hundred galls examined in the present case, no case of *Rhyncothrips* was found, but in some galls *Androthrips flavipes* was observed. It is interesting to note that at first sight these are prone to be identified as new species, because of their strikingly different coloration. Karny (4) has already described three different varieties of *Androthrips flavipes* on basis of coloration. The present one, while conforming to the general characters of the species, is different from the other three recorded varieties in :—vertex and middle region of head, all legs deep lemon yellow; antennal joints 3, 4, 5, & 6 yellow; joints 1 &2 dark brown; 7 & 8 dark grey; thorax strewn all over with dark pigment, over an otherwise lemon yellow background; abdomen dark brown, with yellow streaks at middle. Duplicate cilia of wings 8. *Androthrips* occurs on an average about 6-8 in each gall. The ratio of *Androthrips* to *Arrhenothrips* in the galls in general 1 : 12.



Mimusopus elengi galled and damaged by *Arrhenothrips ramakrishnae*.

PREDATORS

Ramakrishna has recorded a single instance of an Anthocorid bug, *Montondoniola thripodes* Berg, feeding on the immature stages of *Arrhenothrips*. The author in the course of this work has found several nymphs and adults of another small Anthocorid bug, *Septicus* sp. feeding on the eggs and other larval stages of Arrhenothrips. There is considerable number of records of

Anthocorid insect predators which act as efficient natural enemies of a number of species of thrips attacking truck crops and fruit trees. The nymphs and adults of *Septicus* are quick in their movements and blood-red in colour, the adults measuring about 2.5 mms.

ACKNOWLEDGMENTS

I wish to express my sincere thanks to Prof. M. S. Mani, for having gone through this paper. My thanks are also due to Dr. A. P. Kapur, Zoological Survey of India, for identification of the Anthocorid cug.

REFERENCES

1. BAGNALL. 1924. *Ann. Mag. Nat. Hist.*, (9) **14** : 635.
2. CLAUSEN. 1940. Entomophagous Insects p. 589.
3. HOOD. 1919. *Insec. Inscit. Menstr.*, **8** : 99-101.
4. KARNY. 1926. *Ent. Mem. Dep. Agric. India.*, **9** (6) : 210.
5. RAMAKRISHNA. 1928. *Ent. Mem. Dep. Agric. India.*, **10** (7) : 82.
6. MANI, M. S. 1948. *J. R. Asiatic Soc. Bengal*, (Sci.) **14** (2).
7. RAMAKRISHNA & MARGABANDHU. 1940. *Cat. Indian Insects*, **25** : 31

GROWTH OF BOUNDARY LAYER OVER AN INFINITE PLATE IN A COMPRESSIBLE FLUID— NON-ADIABATIC FLOW

By M. Ray, *Agra College, Agra.*

1. Introduction

Boundary layer equations for a compressible fluid have often been used for studying steady laminar flow over a flat plate. Velocity and temperature distributions in the boundary layer for a steady flow of a perfect gas over a plate have been found out both when the Prandtl number is unity (1) and also when it is different from unity (2). The corresponding cases for a liquid have been worked out by the present author (3) as non-steady and non-adiabatic flow. Similar method has been used in this paper for a compressible fluid on the assumption that the specific heat is constant and Prandtl number is unity. The energy equation gives at once the Crocco's relation for the temperature distribution and the fundamental equations have been transformed by a transformation of variables which permits of an easy solution with the help of gas law and a plausible assumption between the coefficient of viscosity and temperature.

2. Basic Equations

Let the axis of x be taken parallel to the plate in the direction of main stream, the axis of y normal to the plate from its surface; (u, v) components of velocity, ρ the density, μ the coefficient of viscosity and i the heat content. Let U be the velocity of the main stream. Let us take the ensuing flow in the boundary layer to be non-steady and non-adiabatic, so that the equation of motion is

$$\rho\left(\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right)=\frac{\partial}{\partial y}\left(\mu\frac{\partial u}{\partial y}\right) \qquad (1)$$

The equation of continuity is

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x}(\rho u) + \frac{\partial}{\partial y}(\rho v) = 0. \tag{2}$$

When the Prandtl number is Unity, the equation of energy is

$$\rho\left(\frac{\partial i}{\partial t} + u\frac{\partial i}{\partial x} + v\frac{\partial i}{\partial y}\right) = \frac{\partial}{\partial y}\left(\mu\frac{\partial i}{\partial y}\right) + \mu\left(\frac{\partial u}{\partial y}\right)^2 \tag{3}$$

From (1) and (3) we get at once the Crocco's relation

$$i_0 - i = (i_0 - i_1)\frac{u}{n} - \tfrac{1}{2}(U - u)u, \tag{4}$$

where the suffix 0 refers to quantities measured at the plate and suffix 1 to quantities at large normal distance from the plate.

To simplify equations (1) and (2) we note that the velocity profile will be the same across any section perpendicular to the plate, so that all quantities can be taken to be independent of x.

The equations (1) and (2) become

$$\rho\frac{\partial u}{\partial t} + \rho v\frac{\partial u}{\partial y} = \frac{\partial}{\partial y}\left(\mu\frac{\partial u}{\partial y}\right) \tag{5}$$

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial y}(\rho v) = 0. \tag{6}$$

We have to solve these equations under the following conditions

$$(a) \quad \text{at } y=0; \quad u=0, \quad v=0 \tag{7}$$

$$\left.\begin{aligned} (b) \quad \text{at } y=\infty; \; u=U; \; \frac{\partial u}{\partial y} &= 0, \\ \rho=\rho_1, \; \mu &= \mu_1. \end{aligned}\right\} \tag{8}$$

The equation (6) is satisfied by

$$\rho = \frac{\partial \psi}{\partial y}, \quad \rho v = -\frac{\partial \psi}{\partial t}. \tag{9}$$

We now change the independent variables (t, y) to (t, ψ) by means of the transformation formulae

$$\left.\begin{aligned} \left(\frac{\partial}{\partial y}\right)_t &= \rho\left(\frac{\partial}{\partial \psi}\right)_t, \\ \left(\frac{\partial}{\partial t}\right)_y &= -\rho v\left(\frac{\partial}{\partial \psi}\right)_t + \left(\frac{\partial}{\partial t}\right)_\psi \end{aligned}\right\} \tag{10}$$

The equation (5) then becomes

$$-\rho^2 v\frac{\partial u}{\partial \psi}+\rho\frac{\partial u}{\partial t}+\rho^2 v\frac{\partial u}{\partial \psi}=\rho\frac{\partial}{\partial \psi}\left(\mu\rho\frac{\partial u}{\partial \psi}\right)$$

$$\text{or }\frac{\partial u}{\partial t}=\frac{\partial}{\partial \psi}\left(\mu\rho\frac{\partial u}{\partial \psi}\right). \tag{11}$$

To solve (11) we make use of the gas equation, namely,

$$i\rho=\text{const.}=i_1\rho_1 \tag{12}$$

and we further assume

$$\frac{\mu}{\mu_1}=\frac{i}{i_1}. \tag{13}$$

With the help of these two relations, we get from (11)

$$\frac{\partial u}{\partial t}=\mu_1\rho_1\frac{\partial^2 u}{\partial \psi^2}. \tag{14}$$

3. *Solutions of the Equations:*

We take the solution of equation (14) as

$$u=U\ erf\,(\eta) \tag{15}$$

$$\text{when}\quad \eta=\frac{\psi}{2\sqrt{\mu_1\rho_1 t}} \tag{16}$$

Now from definition we have

$$d\psi=\left(\frac{\partial \psi}{\partial t}\right)_\eta dt+\left(\frac{\partial \psi}{\partial \eta}\right)_t d\eta=\left(\frac{\partial \psi}{\partial y}\right)_t dy+\left(\frac{\partial \psi}{\partial t}\right)_y dt$$

$$\text{where } \psi=2\sqrt{\mu_1\rho_1}\,t^{\frac{1}{2}}\eta.$$

$$\therefore\ \sqrt{\mu_1\rho_1}\,t^{-\frac{1}{2}}\eta\,dt+2\sqrt{\mu_1\rho_1}\,t^{\frac{1}{2}}\,d\eta=\rho dy-\rho v dt$$

$$\text{giving }\ \rho v=-\sqrt{\mu_1\rho_1}\,t^{-\frac{1}{2}}\eta \tag{17}$$

$$\text{and }\ \rho dy=2\sqrt{\mu_1\rho_1}\,t^{\frac{1}{2}}\,d\eta. \tag{18}$$

From (17) we see that $v=0$ when $\eta=0$, thus $\eta=0$ corresponds to $y=0$.

From (18) we get

$$dy=2\sqrt{\mu_1\rho_1}\quad\frac{t^{\frac{1}{2}}}{\rho}d\eta$$

$$=2\sqrt{\mu_1\rho_1}\;\frac{i\,t^{\frac{1}{2}}}{i_1\rho_1}d\eta, \qquad \text{from (12)}$$

$$=\frac{2\sqrt{\mu_1\rho_1}}{i_1\rho_1}\left[i_0-(i_0-i_1)\frac{u}{u}+\tfrac{1}{2}(u-u)u\right]\quad t^{\frac{1}{2}}\;d\eta, \qquad \text{from (4)}$$

$$=\frac{2\sqrt{\mu_1\rho_1}t}{i_1\rho_1}\left[\;i_0-\left(\;i_0-i_1-\frac{u^2}{2}\right)erf\,(\eta)-\frac{u^2}{2}erf^{\,2}(\eta)\;\right]d\eta,$$

from (15)

Hence $y=\frac{2\sqrt{\mu_1\rho_1}}{i_1\rho_1}\;t^{\frac{1}{2}}\;\Big[i_0\eta-\left(\;i_0-i_1-\frac{u^2}{2}\right)\left\{\eta\;erf\,(\eta)+\frac{1}{\sqrt{\pi}}\left(\;e^{-\eta^2}-1\right)\right\}$

$$-\frac{u^2}{2}\left\{\eta\;erf^{\,2}(\eta)+\frac{2}{\sqrt{\pi}}\;e^{-\eta^2}erf\,(\eta)-\frac{4}{\pi}\int_0^{\eta}\;e^{-2\eta^2}\;d\eta\;\right\}\Big]$$

$$=\frac{2\sqrt{\mu_1\rho_1}}{i_1\rho_1}\quad t^{\frac{1}{2}}\;\Big[i_0\eta-\left(i_0-i_1-\frac{u^2}{2}\right)\Big\{\;\eta\;erf\,(\eta)+\frac{1}{\sqrt{\pi}}$$

$$\left(\;e^{-\eta^2}-1\;\right)\Big\}-\frac{u^2}{2}\Big\{\eta\;erf^{\,2}(\eta)+\frac{2}{\sqrt{\pi}}\;e^{-\eta^2}erf\,(\eta)$$

$$-\sqrt{\frac{2}{\pi}}erf\,(\sqrt{2}\eta)\;\Big\}\Big] \tag{19}$$

as $y=0$ when $\eta=0$.

This shows that $y\longrightarrow\infty$ corresponds to $\eta\longrightarrow\infty$.

Further

$$\frac{\partial u}{\partial y}=\rho\;\frac{\partial u}{\partial\psi}=\frac{\rho u}{\sqrt{\pi\mu_1\rho_1}}\;\frac{e^{-\eta^2}}{t^{\frac{1}{2}}}$$

so that condition $\frac{\partial u}{\partial y}=0$ is satisfied when

$$\eta\longrightarrow\infty\quad i.\,e.\;y\longrightarrow\infty.$$

Thus our solution (15) makes $u=0$ when $\eta=0$ $(y=0)$,

u practically equal to U when η is large and theoretically equal to U when $\eta=\infty$ $(y=\infty)$.

From (17) we see that $v=0$ when $\eta=0$ $(y=0)$.

But when $\eta \longrightarrow \infty$, y tends to

$$\frac{2\sqrt{\mu_1\rho_1}}{i_1\rho_1}\, t^{\frac{1}{2}}\eta \left[i_0 - \left(i_0 - i_1 - \frac{U^2}{2} \right) - \frac{U^2}{2} \right] = 2\sqrt{\frac{\mu_1}{\rho_1}}\; t^{\frac{1}{2}}\eta.$$

Therefore $v = -\dfrac{\sqrt{\mu_1\rho_1}}{\rho}\; t^{-\frac{1}{2}}\eta$ tends to $-\dfrac{\rho_1 y}{2\rho t}$ and becomes infinite.

Thus the solution theoretically fails for infinite values of η.

But for moderate values of η, at which u is practically equal to U, v is of the order $\dfrac{\sqrt{\mu_1\rho_1}}{\rho\sqrt{t}}$. Since we are interested in the final velocity profile, this creates no trouble.

We further note that from (4) we have

$$\frac{\partial i}{\partial y} = \left(\frac{1}{2}\, U - \frac{i_0 - i_1}{U} \right) \frac{\partial u}{\partial y} - u\, \frac{\partial u}{\partial y}.$$

On the plate $y=0$ $u=0$ but $\dfrac{\partial u}{\partial y}$ is not equal to zero, therefore $\dfrac{\partial i}{\partial y}$ can be zero only when $i_0 - i_1 = \frac{1}{2}U^2$

Thus there is no transfer of heat by conduction from the plate if

$$i_0 - i_1 = \tfrac{1}{2}\, U^2.$$

This result is the same as in references (2) and (3).

REFERENCES

1. Von Mises. R, Friedrichs K. O. 1941. Fluid Dynamics (Brown University) 248-250.
2. Young A. D. 1948. *Quart. J. mech. appl. math.* (Oxford) 1 : 70.
3. Ray M. 1952. *Bull. Calcutta math. Soc.*, **44** : 137-141.

CONDENSATION OF MALON-1.3.4-XYLIDIC ACID WITH AROMATIC ALDEHYDES

PART III. WITH HALOGEN AND NITRO SUBSTITUTED SALICYLALDEHYDES

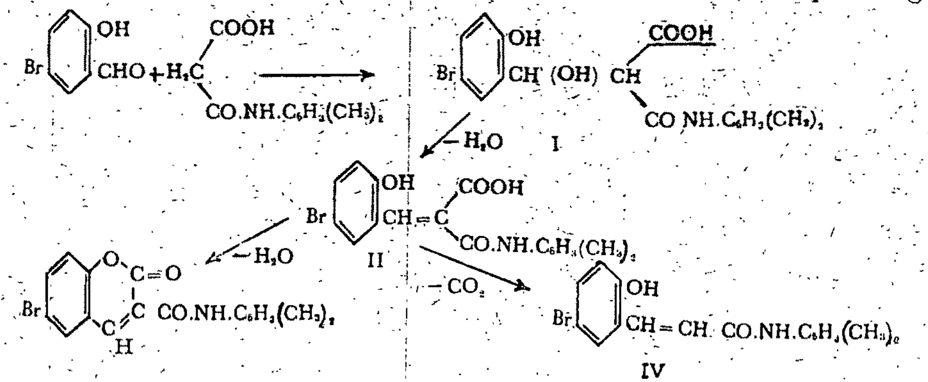
By SANT PRAKASH and P. I. ITTYERAH, *Chemistry Department, St. John's College, Agra.*

In an earlier paper (3) the preparation of malon-1.3.4-xylidic acid and its condensation with a few aromatic aldehydes have been reported. In this journal (4) the condensation of this acid with the three mono hydroxybenzaldehydes, the three mono methoxybenzaldehydes, vanillin, veratraldehyde, piperonal and 5-bromo-vanillin has been reported. Salicylaldehyde when condensed with malon-1.3.4-xylidic acid gave coumarin-3-carboxy-1.3.4-xylidide. A trace of pyridine was found to be the best catalyst in these condensations.

The present paper deals with the condensation of some substituted salicylaldehydes with malon-1.3.4-xylidic acid. The aldehydes selected were 5-chlorosalicylaldehyde, 3.5-dichlorosalicylaldehyde, 5-bromosalicylaldehyde, 3.5-dibromo-salicylaldehyde, 3-nitro-salicylaldehyde and 5-nitro-salicylaldehyde. These aldehydes were prepared from pure salicylaldehyde and then condensed with the acid. Various experimental conditions were tried.

Taking 5-bromo-salicylaldehyde as an example, condensation of these aldehydes with the acid can be represented as follows :- Products of the type III could be isolated in every reaction. They were all yellow in colour. Products of types I, II and IV could not be isolated in any case.

Another peculiar feature was that in each condensation along with the yellow coumarin derivative (Type III) a deep orange substance was also formed. This could easily be separated from the coumarin derivative by boiling the mixture with alcohol. The orange substance being soluble in alcohol, dissolved and the coumarin derivative being very sparingly soluble remained as a residue. On cooling the alcoholic extract deep orange needle shaped crystals were obtained. Substances thus isolated and purified were analysed and they were found to be the corresponding



I. is the aldol product.

II. 2-Hydroxy-5-bromo-benzalmalonic acid.

III. 6-Bromo-coumarin-3-carboxy-1.3.4-xylidide.

IV. 2-Hydroxy-5-bromo-cinnam-1.3.4-xylidide.

hydroxy-benzal-1.3.4-xylidines. The formation of these compounds can only be explained by assuming that during the reaction malon-1.3.4-xylidic acid molecule breaks down—probably due to hydrolysis—into malonic acid and 1.3.4-xylidine. The primary amine thus obtained condenses with the aldehyde. In each case the identity of the product was further confirmed by synthesising it from the corresponding aldehyde and pure 1.3.4 xylidine. This side reaction seems to be a peculiarity with salicylaldehyde and its derivatives. *m*-and *p*-Hydroxybenzaldehydes, the monomethoxybenzaldehydes, vanillin, veratraldehyde, piperonal and 5-bromo-vanillin did not give any such products. It cannot be attributed to the use of any condensing agent as these products were formed both in the presence and in the absence of condensing agents. A satisfactory explanation can only be given after collecting more data and work in this direction is in progress in this laboratory.

Regarding the use of organic bases as condensing agents in these reactions, a trace of pyridine was found the best. For example in the condensation of 5-chloro-salicylaldehyde and malon-1.3.4-xylidic acid, the yields of 6-chloro-coumarin-3-carboxy-1.3.4-xylidide were 12.2%, when no condensing agent was used, 24.3% when a trace of piperidine was used and 48.6% when a trace of pyridine was used. Under similar conditions 3.4-dicholoro-salicylaldehyde gave 13%, 25%, and 53% yields of 6.8-dichloro-coumarin-3-carboxy-1.3.4-xylidide.

EXPERIMENTAL

Preparation of malon-1.3.4-*xylidic acid.* The method followed was the one prescribed by Ittyerah and Chellappa (3). From 10 g. of freshly distilled xylidine (1.3.4.) and 15 g. of diethyl malonate, 8g. of malon-1.3.4-xylidic acid was obtained. It melted with decomposition at 154° C.

Preparation of 5-*chloro-salicylaldehyde.* The method followed was that of Blitz and Stepf (2). From 5 g. of salicylaldehyde 4.8 g. of 5-chloro-salicylaldehyde could be obtained. In a second preparation a small quantity of iodine was added as a catalyst and the yield of 5-chloro-salicylaldehyde was slightly better. The aldehyde melted at 101° C.

Condensation of 5-*chloro-salicylaldehyde with malon*-1.3.4-*xylidic acid : formation of* 6-*chloro-coumarin*-3-*carboxy*-1.3.4-*xylidide and* 2-*hydroxy*-5-*chloro-benzylidene*-1.3.4-*xylidine.*

1.9 g. of malon-1.3.4-xylidic acid and 1.7 g. of 5-chloro-salicylaldehyde were mixed well and taken in a small round bottomed flask. The flask was then heated in an oil bath at 100° C. for four hours. The mixture first melted to an orange coloured liquid and after three hours, set to a solid mass of the same colour. The mass left after heating was extracted with a strong solution of sodium bicarbonate. The alkali extract was then acidified with excess of hydrochloric acid but there was no precipitate.

The residue left in the flask was then transferred to a filter and washed several times with small quantities of hot alcohol. 0.2 gm. of a canary yellow coloured substance was left on the filter paper. It melted at 216° C. On analysis it was identified to be 6-chloro-coumarin-3-carboxy-1.3.4-xylidide.

Found: Chlorine, 10.88% : $C_{18}H_{14}O_3NCl$ requires 10.83%.

The alcoholic extract on cooling deposited 0.3 g. of an oarnge red crystalline substance. This was further purified by recrystallisation from alcohol. On analysis it was found to be 2-hydroxy-5-chloro-benzylidene-1.3.4-xylidine. This melted at 110° C. With ferric chloride it gave a violet colour.

Found: Chlorine, 13.56 %: $C_{15}H_{14}O_3NCl$, requires 13.67%.

In another experiment the same quantities of the acid and the aldehyde were taken and two drops of pyridine were added and the mixture heated for four hours at 100° C. On extraction 0.8 g. of 6-chloro-coumarin-3-carboxy-1.3.4-xylidide and 0.4 g. of 2-hydroxy-5-chloro-benzylidene-1.3.4-xylidine were obtained.

In a third experiment when piperidine was used in place of pyridine a lot of resinous matter was formed and the yield of 6-chloro-coumarin-3-carboxy-1.3.4-xylidide was only 0.4 g. and that of 2-hydroxy-5-chloro-benzylidene-1.3.4-xylidine was 0.3 g.

Preparation of 3.5-*Dichlorosalicylaldehyde.* The method followed was that of Biltz and Stepf (2). The yield was about 77% and melting point 95° C.

*Condensation of malon-*1.3.4-*xylidic acid with* 3.5-*dichloro-salicylaldehyde : formation of* 6.8-*dichloro-coumarin-*1.3.4-*xylidide and* 2-*hydroxy-*3.5*dichloro-benzylidene-*1.3.4-*xylidine.* On heating a mixture of 1.2 g. of malon-1.3.4-xylidic acid and 1 g. of 3.5-dichlorosalcylaldehyde at 100° for four hours and then extracting in the same manner as described earlier 0.2 g. of 6.8-dichloro-coumarin-1.3.4-xylidide and 0.3 g. of 2-hydroxy-3.5-dichloro-benzal-1.3.4-xylidine were obtained.

The coumarin derivative was yellow in colour and after purification by repeated washing with hot alcohol it melted at 230° C. It was very sparingly soluble in all the common organic solvents. It dissolved in caustic soda and could be reprecipitated from it by adding excess of dilute sulphuric acid. It decolourised alkaline potassium permanganate.

Found,: Chlorine, 20.03%: $C_{18}H_{13}O_3NCl_2$ requires 19.6%.

The benzal-xylidine obtained was very soluble in alcohol, acetone and benzene. After recrystallisation from alcohol it melted at 110° C. It gave a deep violet colour with ferric chloride.

Found : Chlorine, 24.33% : $C_{15}H_{13}ONCl_2$ requires 24.1%.

In another experiment when a trace of pyridine was used the yield of 6.8-dichloro-coumarin-3-carboxy-1.3.4-xylidide rose to 0.8 g. and that of 2-hydroxy-3.5-dichloro-benzal-1.3.4-xylidine to 0.5 g. When piperdine was used in place of pyridine there was resin formation and the yields were poor.

Preparation of 5-*Bromo-salicylaldehyde.* The method followed was that of Auwers and Burger (1). From 5 g. of salicylaldehyde 6.2 g. of 5-bromo-salicylaldehyde could be obtained.

Condensation of malon-1.3.4-*xylidic acid with* 5-*bromo-salicylaldehyde : formation of* 6-*bromocoumarin*-3-*carboxy*-1.3.4-*xylidide and* 2-*hydroxy*-5-*bromo-benzal*-1.3.4-*xylidine.*

On heating a mixture of 2.2 g. of malon-1.3.4-xylidic acid, 2g. of 5-bromo-salicylaldehyde and two drops of pyridine for four hours and extracting the products as in previous cases, 0.9 g. of 6-bromo-coumarin-3-carboxy-1.3.4-xylidide and 0.5 g. of 2-hydroxy-5-bromo-benzal-1.3.4-xylidine were obtained.

6-bromo-coumarin-3-carboxy-1.3.4-xylidide was canary-yellow in colour and melted at 205° C. It decolourised alkaline potassium permanganate solution and bromine water. It dissolved in caustic soda and could be reprecipitated by addition of sulphuric acid. It forms a bromo-derivative m. p. 270° C. and a mercury derivative which melted and decomposed at 230° C. The yields of both the bromo and the mercury derivatives were very small and so no quantitative analysis of these compounds could be carried out. The bromo derivative was prepared by dissolving separately equimolecular quantities of the coumarin and bromine in chloroform and then mixing the two solutions. A light yellow crystalline product separated out the next day. This was filtered and recrystallised from alcohol.

The mercury derivative was prepared by dissolving equimolecular quantities of mercuric oxide and the coumarin separately in hot glacial acetic acid and then mixing the two solutions. After two hours a pale yellow crystalline precipitate was formed. This melted with decomposition at 230° C.

The bromine content of 6-bromo-coumarin-3-carboxy-1.3.4-xylidide was estimated by fusion method.

Found, Chlorine = 21.61% : $C_{18}H_{14}O_3N$ Br requires 21.01%.

2-Hydroxy-5-bromo-benzal-1.3.4-xylidine was obtained as an orange crystalline substance. It melted at 85° C.

Found: Bromine; 26.27% : $C_{15}H_{14}O$ N Br requires 26.3%.

Preparation of 3.5-Dibromosalicylaldehyde. To 6.1 g. of salicylaldehyde was added 5.8 c.c. of bromine from a burette drop by drop with vigorous shaking. The mass solidified when about 2 c.c. of bromine were added but again became liquid on further addition of bromine. The flask was kept at room temperature for two days. On the third day the solid mass was crushed with about 500 c.c. of water. The solid left was filtered and recrystallised from dilute alcohol. Yield 12.5 g. It melted at 83° C.

Condensation of 3.5-*Dibromosalicylaldehyde with malon*-1.3.4-*xylidic acid : formation of* 6.8-*dibromo-coumarin*-3-*carboxy*-1.3.4-*xylidide and* 2-*Hydroxy*-3.5-*dibromo-benzal*-1. 3.4-*xylidine.*

On heating at 100° for four hours a mixture of 2 g. of malon-1.3.4-xylidic acid, 2 g. of 3.5-dibromosalicylaldehyde and two drops of pyridine an orange yellow solid mass was obtained. This was boiled with about 15 c.c. of alcohol. A canary yellow residue was left. This after repeated washing with alcohol weighed 1 g. and melted at 255° C. On analysis it was found to be 6.8-dibromo-coumarin-3carboxy-1.3.4-xylidide.

Found: Bromine = 37.93% : $C_{18}H_{13}O_3N$ Br_2 requires 37.6%.

The alcoholic extract on cooling deposited needle shaped orange coloured crystals. The yield was 0.7 g. This was analysed and found to be 2-hydroxy-3.5-dibromo-benzal-1.3.4-xylidine. It melted at 101° C.

Found : Bromine 42.1% : $C_{15}H_{13}O\,N\,Cl_2$ requires 41.7%.

Preparation of 3-*and* 5-*Nitrosalicylaldehydes*. The method followed was that recommended by Miller (5). Starting from 6 g. of salicylaldehyde and nitrating with fuming nitric acid in galcial acetic acid medium 6.9 g. of a mixture of the two aldehydes was obtained. During nitration the temperature was kept between 0° and 4° C. The sodium salts of these aldehydes were then prepared and they were separated from one another by fractional crystallisation from water. Salt of 5-nitrosalicylaldehyde being less soluble separated out first. The aldehydes were liberated from their salts by strong hydrochloric acid. 5.Nitrosalicylaldehyde weighed 4.2 g. and melted at 126° C. 3-Nitrosalicylaldehyde weighed .5 g. and melted at 110° C.

Condensation of malon-1.3.4-*xylidic acid with* 5-*nitro-salicylaldehyde : formation of* 6-*nitro-coumarin*-3-*carboxy*-1.3.4-*xylidide and* 2-*hydroxy*-5-*nitro-benzal*-1.3.4-*xylidine.*

2 g. malon-1.3.4-xylidic acid, 2 g. 5-nitrosalicylaldehyde and two drops of pyridine were heated in a round bottomed flask for four hours at 100° C. The mixture first melted to a yellow liquid but soon set to an orange solid. On extraction in the manner described in previous experiments two products were obtained. One was an yellow crystalline compound and its melting point was 230° C. It was soluble in caustic soda and could be reprecipitated by the addition of acid. On analysis it was found to be 6-nitro-coumarin-3-carboxy-1.3.4-xylidide.

Found : Nitrogen, 8.08% : $C_{18}H_{14}O_5N_2$ requires 8.2%.

The other was a deep yellow crystalline solid readily soluble in alcohol. This was found to be 2-hydroxy-5-nitro-benzal-1.3.4-xylidine. It melted at 167° and weighed 0.5 g.

Found : Nitrogen, 10.35% : $C_{15}H_{14}N_2O_2$ requires 10.3%.

Condensation of 3-*nitrosalicylaldehyde with malon*-1.3.4-*xylidic acid : formation of* 8-*nitro-coumarin*-3-*carboxy*-1.3.4-*xylidide and* 2-*hydroxy*-3-*nitro-benzal*-1.3.4-*xylidine.*

2 g. of malon-.3.4-xylidic acid, 2 g. of 3-nitrosalicylaldehyde and two drops of pyridine were heated together for four hours on a water bath. On extraction two products were obtained. One was very sparingly soluble in alcohol and the other was soluble. So they could easily be separated from one another. The first one was yellow in colour and melted at 255° C. On analysis it was found to be 8-nitro-coumarin-3-carboxy-1.3.4-xylidide.

Found: Nitrogen, 8.22% : $C_{18}H_{14}O_5N_2$ requires 8.2%.

The second product was yellowish orange in colour and on analysis was found to be 2-hydroxy-3-nitro-benzal-1.3.4-xylidine.

Found : Nitrogen, 10.41% : $C_{15}H_{14}N_2O_3$ requires 10.3%

SUMMARY

5-Chloro-salicylaldehyde, 3.5-dichloro-salicylaldehyde, 5-bromo-salicylaldehyde, 3.5-dibromosalicylaldehyde, 3-nitrosalicylaldehyde and 5-nitro-salicylaldehyde were prepared and condensed with malon-1.3.4-xylidic acid. The following coumarin derivatives were obtained for the first time : 6-chloro-coumarin-3-carboxy-1. 3. 4-xylidide, m. p. 216°, 6.8-dichloro-coumarin-3-carboxy-1.3.4-xylidide, m. p. 230°, 6-bromo-coumarin-3-carboxy-1.3.4-xylidide, m. p. 205°, 6.8-dibromo-coumarin-3-carboxy-1.3.4-xylidide, m. p. 255° 8-nitro-coumarin-3-carboxy-1.3.4-xylidide, m. p. 255° and 6-nitro-coumarin-3-carboxy-1.3.4-xylidide. m. p. 230°.

In each condensation it was noted that part of the malon-1.3.4-xylidic acid used broke down to xylidine (1,3.4) and xylidine thus formed condensed with the aldehyde to form the corresponding benzal-xylidine. Thus 2-hydroxy-5-chloro-, 2-hydroxy-3.5-dichloro-, 2-hydroxy-5-bromo-, 2-hydroxy-3.5-dibromo, 2-hydroxy-3-nitro-, and 2-hydroxy-5-nitro-, benzal-1.3.4-xylidines were obtained. This type of breaking down of malon-1.3.4-xylidic acid has been found to occur only in the presence of salicylaldehyde and its derivatives.

Pyridine in traces was found to be the best catalyst in these reactions. Of the aldehydes used 3.5-dichloro- and 3-nitro-salicylaldehydes were the most reactive.

REFERENCES

1. AUWERS and BURGER, 1904. *Ber.*, **37** : 3934.
2. BILTZ and STEPF, 1904. *ibid.*, **37** : 4031.
3. CHELLAPPA, P. T. and P. I. ITTYERAH. 1953. *J. Indian chem. Soc.* (**30**)**6** : 388.
4. GHATAK, S. & P. I. ITTYERAH. 1954. *Agra Univ. J. Res.* (Sci.), **3** (2) :
5. MILLER, 1887. *Ber.*, **20** : 1928.

CONDENSATION OF AROMATIC ALDEHYDES WITH MALON-1.3.4-XYLYDIC ACID

PART II.—WITH *o*-, *m*- AND *p*-HYDROXYBENZALDEHYDES, *o*-, *m*- and *p*- METHOXYBENZALDEHYDES, PIPERONAL, VANILLIN, VERATRALDEHYDE, AND 5-BROMO-VANILLIN.

By S. GHATAK, JWALA PRASAD and P. I. ITTYERAH., *Chemistry Department, St. John's College, Agra.*

Preparation of malon-1.3.4-xylidic acid and its condensation with benzaldehyde, *m*-methylbenzaldehyde and *p*-methylbenzaldehyde were reported by Chellappa and Ittyerah (1). This paper deals with the condensation of malon-1.3.4-xylidic acid with the three mono-hydroxybenzaldehydes, the three mono-methoxybenzaldehydes, piperonal, vanillin, veratraldehyde and 5-bromo-vanillin. The condensations were carried out both in the presence and in the absence of condensing agents. The condensing agents used were pyridine, piperidine and glacial acetic acid. Pyridine and piperidine in traces were found to catalyse all the reactions. Glacial acetic acid proved very useful in the case of veratraldehyde condensations.

When no condensing agent was used the corresponding benzylidene-1.3.4-malon-xylidic acid was the only product obtained. Similar was the case when glacial acetic acid was used as the condensing agent. When a trace of pyridine was used there was partial decarboxylation and the product was largely the corresponding cinnam-1.3.4-xylidide mixed with a small quantity of the acid product. When a trace of piperidine was used there was greater decarboxylation and the product was wholly the corresponding cinnam-1.3.4-xylidide.

Salicylaldehyde behaved differently from other aldehydes. It gave coumarin-3-carboxy-1.3.4-xylidide. The yield was poor when compared with other mono-substituted aldehydes. *m*-Methoxy-benzaldehyde, vanillin and 5-bromo-vanillin gave only the corresponding cinnam-1.3.4-xylidides. Piperonal did not condense well with malon-1.3.4-xylidic acid and gave only 22.3 per cent yield of piperonylidene-malon-1.3.4-xylidic acid. This aldehyde has been reported to give excellent yields when condensed with malonic acid (6). malonanilic acid (2) and malon-*o*-, *m*- and *p*-toluidic acids (3).

In similar condensations the inhibitive effect of a hydroxy group ortho to the aldehyde group has been pointed out earlier (4). When the hydroxyl groups in such aldehydes was methylated the inhibitive influence disappeared to a great extent and the methoxy aldehydes condensed with reactive methylene compounds quickly giving better yields and purer products (5). The same has been found true in the present case also.

Among the products reported in this paper coumarin-3-carboxy-1.3.4-xylidide is yellow in colour and all the rest are white crystalline compounds.

EXPERIMENTAL

The general procedure has been to mix equimolecular quantites of the acid and the aldehyde in a round bottomed flask and heat at 100° C. for four hours. In some cases seven hours' heating was necessary. When a condensing agent like pyridine or piperidine was used the base was added in traces, (0.15 mol.) to the mixture of the aldehyde and the acid. After heating the flask was allowed to cool and the contents were extracted with a strong solution of sodium bicarbonate. The alkali extract was then washed with a little ether to remove any free aldehyde. On addition of excess of strong hydrochloric acid to the alkali extract the acid product was precipitated. This was further purified by crystallisation from alcohol or acetone.

The residue left in the flask after extraction with sodium bicarbonate could be purified by crystallisation from alcohol.

The products obtained, with their yields, melting points etc. are given in the table below.

TABLE.

	Name	M. p.	Mol. Formula.	Yield%.	Nitrogen%.		Eq. wt.	
					Found	Req.	Found	Req.
1.	Coumarin-3-carboxy-1. 3. 4-xylidide.	238^0	$C_{18}H_{15}O_3N$	47	4.59	4.7		
2.	*m*-Hydroxy-R_1	200^0	$C_{18}H_{17}O_4N$	50	4.47	4.5	311.5	311
3.	*m*-Hydroxy-R_2	218^0	$C_{17}H_{17}O_2N$	94.7	5.21	5.2		
4.	*p*-Hydroxy-R_1	223^0	$C_{18}H_{17}O_4N$	50	4.48	4.5	310.3	311
5.	*p*-Hydroxy-R_2	220^0	$C_{17}H_{17}O_2N$	67.7	5.16	5.12		
6.	*o*-Methoxy-R_1	214^0	$C_{19}H_{19}O_4N$	41.5	4.41	4.43	323.8	325
7.	*o*-Methoxy-R_2	152^0	$C_{18}H_{19}O_2N$	95.7	4.97	4.98		
8.	*m*-Methoxy-R_2	154^0	$C_{18}H_{19}O_2N$	71	4.99	4.98		
9.	*p*-Methoxy-R_1	222^0	$C_{19}H_{19}O_4N$	23	4.46	4.3	325.8	325
10.	*p*-Methoxy-R_2	198^0	$C_{18}H_{19}O_2N$	67.8	5.01	4.98		
11.	3.4-Methylene-dioxy-R_1	213^0	$C_{19}H_{17}O_5N$	22.5	4.16	4.1	338.5	339
12.	3.4-Methylene-dioxy-R_2	204^0	$C_{18}H_{17}O_3N$	49.1	4.75	4.74		
13.	3.4-Dimethoxy-R_1	216^0	$C_{20}H_{21}O_5N$	41.5	4.01	3.94	353	355
14.	3.4-Dimethoxy-R_2	181^0	$C_{19}H_{21}O_3N$	81.5	4.43	4.5		
15.	3-Methoxy-4-hydroxy-R_2	154^0	$C_{18}H_{19}O_3N$	27.9	4.71	4.7		
16.	3-Methoxy-4-hydroxy-5-bromo-R_2	196^0	$C_{18}H_{18}O_3NBr$	16.5	3.79	3.72		

$R_1 =$ -benzylidene-malon-1.3.4-xylidic acid.
$R_2 =$ -cinnam-1.3.4-xylidide.

SUMMARY

Malon-1.3.4-xylidic acid was condensed with the three mono-hydroxybenzaldehydes, the three mono-methoxybenzaldehydes, piperonal, vanillin, veratraldehyde and 5-bromo-vanillin. A trace of either pyridine or piperidine was found to catalyse the reaction. Glacial acetic acid was found to be a very good catalyst in the case of veratraldehyde. Salicylaldehyde gave coumarin-3-carboxy-1.3.4-xylidide. With the exception of *m*-methoxybenzaldehyde, vanillin and 5-bromo-vanillin which gave only the corresponding cinnam-1.3.4-xylidide, all the other aldehydes gave two products each (1) the corresponding benzylidene-malon-1.3.4-xylidic acid and (2) the corresponding cinnam-1.3.4-xylidide.

REFERENCES

1. CHELLAPPA, P. T. and P. I. ITTYERAH. 1953. *J. Indian chem. Soc.*, **30** : 6, 388.
2. ITTERAH, P. I. and K. C. PANDYA. 1944. *Proc. nat. Acad. Sci. India*, (A), **14** : 95.
3. ITTYERAH, P. I. and K. C. PANDYA. 1953. *Agra Univ. J. Res.* (*Science*), **2** : 17.
4. ITTYERAH, P. I. and K. C. PANDYA. 1941. *Proc. Indian Acad. Sci.*, (A) **13** : 119.
5. ITTYERAH, P. I. and K. C. PANDYA. 1941. *ibid.*, (A) **13** : 461.
6. VAHIDY, T. A. and K. C. PANDYA. 1935. *ibid.*, **11** : 4,402.

ANALYSIS OF INORGANIC COMPOUNDS BY PAPER CHROMATOGRAPHY

PART III.—STUDY OF VARIOUS FACTORS EFFECTING THE RF VALUES OF CATIONS IN THE SEPARATION OF A MIXTURE OF COPPER, LEAD, BISMUTH, CADMIUM AND MERCURY.

By SWARUP NARAIN TEWARI, *Chemical Examiner's Research Laboratory, Agra.*

ABSTRACT

A study of various physico-chemical factors responsible for the separation and identification of cations has been made. The Rf values on strips or circular filter paper chromatograms of cations have been determined. The influence of concentration, the distance of the solvent front and the distance of the original spot from the apex of the filter paper, and temperature on the Rf values have been studied. The effect of impregnations of filter papers with various electrolytes on the Rf values of cations has also been described.

In previous communications (1 & 2) was reported the studies of the factors responsible for the separation of copper, cobalt and nickel; lead, silver and mercury from their composite mixtures. Lacourt etc. (3) and Harasawa (4) experienced difficulty in the separation of substances having close Rf. values. From primary considerations, it would appear that excellent separations can be achieved by controlling all the possible factors responsible in the chromatographic separation of substances. The present paper deals with the separation of II-A group of cations, keeping in view all the factors responsible for good separation.

Experimental Procedure.—The apparatus both for ascending and horizontal flow of solvents was same as employed for previous separations. Whatman No. I paper was used for the strips as well as for the circular discs (20 cm.). The solvent used was a mixture of n-butanol saturated with 3 N HCL, as recommended by Pollard etc. (5). The mixture to be separated for its constituents was made of the nitrates of lead, copper, bismuth, cadmium and mercury prepared in pure distilled water. Lead was removed from the mixture by precipitating as lead chloride. 0.01 ml of the mixture containing 1 mgm of each cation was spotted on the paper. The procedure for running the chromatograms was same as described earlier (2).

The chromatograms after development with the solvent were dried at 60°c in hot air oven for about 20 minutes and were then sprayed with 0.1% solution of dithizone in chloroform (addition of a small quantity of ethyl alcohol to the mixture helped the drying of the chromatogram quickly after spraying with the reagent).

Results.—Rf values in Table I indicate the effect of concentration on the separation of individual cations from their mixture at the room temperature (20°±1).

Table I

Rf values of cations.

Cations	Rf values at different concentration						
	0.1 mgm	0.2 mgm	0.3 mgm	0.4 mgm	0.5 mgm	0.7 mgm	1.0 mgm
Copper	0.25	0.26	0.28	0.30	0.32	0.35	0.40
Bismuth	0.50	0.52	0.55	0.59	0.62	0.65	0.68
Cadmium	0.63	0.65	0.67	0.70	0.72	0.74	0.77
Mercury	0.72	0.75	0.77	0.80	0.83	0.86	0.89

Thus the Rf values of copper, bismuth, cadmium and mercury increase with the increase in their amounts in the mixture. However, at higher concentration diffused bands were obtained.

Temperature was found to have played a great role in the separation of cations from the mixture. The Rf values of cations were found to be gradually decreasing at higher temperatures. Circular sheets of Whatman No. I were used for studying the effect of temperature by employing the horizontal migration method for irrigating the chromatograms.

Table II

Effect of temperature on the Rf values

Cations	Rf values at temperature				
	5°c	10°c	20°c	30°c	40°c
Copper	0.38	0.36	0.32	0.25	0.20
Bismuth	0.67	0.64	0.59	0.54	0.49
Cadmium	0.81	0.78	0.74	0.66	0.60
Mercury	0.93	0.89	0.84	0.78	0.72

The usual chromatographic ascending technique was employed as described in previous communications for the study of the effect of the movement of the solvent front from the apex. It has been noted that the Rf values decrease for the greater movement of the solvent front from the original spot.

Table III

Temperature 20°c

Cations	Rf values	
	Solvent front 15 cms	Solvent front 26 cms.
Copper	0.40	0.32
Bismuth	0.65	0.56
Cadmium	0.79	0.71
Mercury	0.89	0.82

The change in the Rf values with the increase in the solvent front may be attributed to the variation in the solvent composition owing to the absorption of water by the fibres of the filter paper strips. The order of the separation of the cations however, remains the same.

The observations of Bock and Bock (6) showed that the saturation of the aqueous medium of the solvents with electrolyte has an effect on the partition coefficient between water and ether. Impregnation of filter papers with hydroxides of aluminium and chromium and with silica were employed by Vanyarkho and Garanina (7) and also by Yoshinaga Oka and Akira Murata (8) for the separations of inorganic cations and plant extractives. Recently filter paper impregnated with salts has been used by Lederer (9) for the analysis of inorganic cations. Hence it was thought necessary to see the effect of the salt impregnated papers on the better separation of the inorganic cations from their mixture by chromatographic analysis. The usual horizontal-migration technique was used for the development of the chromatograms at the temperature 15°c. The circles of Whatman no. I paper were impregnated with normal solutions of Kcl, Nacl, and NH_4cl and air dried at room temperature. The solvent butanol saturated with 3 N.HCl was tried and the separation of Cu^{+2}, Bi^{+3}, Cd^{+2}, and Hg^{+2}, examined (Table IV).

Table IV.

Rf values with butanol/3N.HCl on Whatman no. I paper.

Cation	Paper impregnated with			
	…………	KCl	NaCl	NH_4Cl
Copper	0.30	0.25	0.30	0.27
Bismuth	0.60	0.45	0.40	0.38
Cadmium	0.70	0.55	0.52	0.47
Mercury	0.86	0.68	0.66	0.58

Thus the Rf values of copper, bismuth, cadmium and mercury varies with the cation of the impregnated salt solution on the filter paper. It has been noticed that the separation of the respective cations on the impregnated papers was not so marked as was on the untreated paper. The bands of bismuth (yellow) and cadmium (violet) were found to be diffused within those of copper (grey) and mercury (pink) respectively. Moreover, the large difference in the Rf values of cations on the impregnated paper with those on the untreated paper may be ascribed to the formation of complexes with the chloride ions. The increase in chloride ion concentration thus changes the ionic species of the metallic complexes and hence the partition-coefficient of the system. Another interesting thing observed is, that the nature of cations impregnated in the paper also play an important role in the variation of the Rf values of cations separated. The Rf values noted on the untreated paper are more close to the Rf on the paper impregnated with KCl solution. The deviation in the Rf values can be shown in following decreasing order with respect of the cations of the salts impregnated on the paper;—Untreated paper $>K^+ >Na^+ >NH_4^+$. A detailed study is in progress which will throw further light on the problem.

The author wishes to express his thanks to Dr. N. Ghatak D. Sc., Chemical Examiner to the U. P. Government for his keen interest and the special facilities given for carrying out these investigations.

REFERENCES

1. TEWARI, S. N. 1954. Proc. Indian Sci. Cong. Abst. pp. 51. *Koll. Z.* **135** : 186.
2. TEWARI, S. N. 1954. *Kou. Z.*, **135** : 159
3. LACOURT, A. etc. 1949. *Mikrochem. Mikrochim. Acta.*, **34** : 215, 36/37 : 117, (1951).
4. HARASAWA, S. 1951. *J. chem. Soc., Japan*, **72** : 236-39.
5. POLLARD, F. H. etc. 1949. *Nature*, **163**, 598.
6. BOCK, R. and BOCK, E. 1949. *Naturwissnschaften.*, **36** : 344.
7. VANYARKHO, L. G. and GARANINA V. A. 1952. *Aptechnoe Delo.*, **3** : 22-5.
8. YOSHINAGA OKA and AKIRA MURATA. 1951. *Sci. Repts. Research Inst., Tohoku, Japan.* **3A**(I) : 82.
9. LEDERER, M. 1952. *Anal. Chem. Acta.*, **7** : 458-61.

STUDIES ON THE MANURING OF WHEAT

II—EFFECT OF EXCESSIVE NITROGENOUS MANURING ON WHEAT

By RANVIR SINGH and N. K. ANANT RAO, *Department of Agronomy, B. R. College, Agra.*

INTRODUCTION

Majority of the experimental results obtained in India and abroad agree in demonstrating that the yields of almost every crop can be increased appreciably by applying nitrogenous fertilizers. The yields increase with increasing levels of nitrogen upto a certain limit, which is determined by soil, climate, cultivation and the amount of other nutrients present in the soil. Thus the application of optimum amount of nitrogen, which depends upon the above factors, will give the highest yield, and increase in the amount of nitrogen beyond this optimum level may not only be ineffective but may also have deleterious action on the crop, which may finally be responsible for the reduction in the yield. Cowie (1), Garner and Sander (3) and Harris (4) reported an appreciable decrease in the grain yield of wheat as a result of excessive nitrogenous manuring.

The application of nitrogen in excess diminishes the germinative capacity of the seeds leading to gappy stand. Shive (10) reported that heavy application of the soluble fertilizers increased the concentration of soil solution and retarded the germination of seeds. This effect was more marked when the moisture content of the soil was low.

Besides this, excessive nitrogenous manuring leads to the most deleterious effect on the wheat crop *i. e.*, lodging, which accounts for an appreciable decrease in both the grain and *bhusa* yield. Misra (5), and Russel and Watson (9) reported that heavy dressings of nitrogen resulted in the lodging of the wheat crop, which in turn reduced the *bhusa* and grain yields appreciably.

The adverse effects of excessive nitrogenous manuring are not only confined to the growth of the crop but extend to the development of the kernels. The latter effect may be due to the lodging of the crop. The findings of Crowther, Tomforde and Mahmoud (2), Murphy (6) and Russell (7) clearly reveal that excessive nitrogenous manuring lowers the weight of 1000 kernels either by shrivelling the grains or by reducing the size of individual kernels.

Thus it is evident that the application of nitrogen in excess means double disadvantage to the farmer *i. e.*, a wastage of the fertilizer on the one hand and reduced yield on the other. The present paper summarizes the results of an experiment on the effects of varying levels of nitrogen on the growth, development and yield of wheat.

MATERIALS AND METHODS

The effects of increasing levels of nitrogen (0, 15, 30, 45, 60, 75, 100 and 105 lbs of nitrogen per acre) applied as ammonium sulphate (19.5 per cent nitrogen), with and without basal dressing of F. Y. M. (0.5%N) at the rate of 20 lbs nitrogen per acre, were studied on wheat Pb. 591 under field conditions during the *rabi* season of 1950-51 at the B. R. College Experimental Farm, Bichpuri (Agra). The farm enjoys typical sub-tropical climate, with extremes of temperature in summer (110° F) and winter (34° F) and receives about 25″ annual rain-fall, which is mostly received from July to September. The wheat crop received four irrigations in all from a canal, with an interval of about one month between successive irrigations. The soil is light loam of average fertility. The results of the mechanical and chemical analyses of the soil are detailed below :—

TABLE I

Results of soil analyses

Mechanical analysis		*Chemical analysis*	
Coarse sand	0.24%	Nitrogen	0.049%
Fine sand	56.38%	Total phosphate	0.074%
Silt	22.34%	Available phosphate	0.013%
Clay	21.04%	Potash	1.290%

The experiment was conducted in split plot design with four replications taking basal and no basal dressing as the main treatments. The size of the net plot was 1/80th of an acre. The application of F. Y. M. was done one month before, while that of ammonium sulphate was done one day before the sowing of wheat by broadcasting on the surface evenly and mixing them with soil by ploughing. The effects of the treatments on the germination, growth and developmental activities of the plants together with their effects on the final yields were studied. As the object of the present paper is only to summarise the adverse effects of excessive nitrogenous manuring of wheat the experimental procedure followed in the study of maximum germination as a percentage of seed sown, lodging and test weight are detailed below.

Germination counts were taken from three random square yards in each plot. The number of seeds per chhatak of the seed sample was counted and with the adopted seed rate of 40 seers per acre the number of seeds sown per square yard was calculated. The maximum germination attained under different treatments was calculated as a percentage of seed sown by the following formula:—

$$\text{Maximum germination percentage} = \frac{\text{Max. No. of seeds germinated per sq. Yd.}}{\text{No. of seeds sown per sq. yd.}} \times 100$$

The studies on lodging relate to the extent of lodging as influenced by different levels of nitrogen and the basal dressing of F. Y. M., its effect on grain and *bhusa* yields of wheat and the calculation of expected yields under different levels of nitrogen if there would have been no lodging at all.

In order to determine the extent of lodging an iron wire frame having 1 sq. ft. meshes was used. The frame was placed in the lodged plots and the number of squares covering the lodged area was noted; the number of squares gave the area of lodged portion in square feet.

To determine the extent of loss in grain and *bhusa* yields due to lodging, 9 feet row lengths from lodged and unlodged patches, taking three feet long rows from three random places were harvested separately from each plot where lodging had occurred.

These samples were threshed separately to record the *bhusa* and grain yield from each of them, to compare the yields from unlodged samples with those from lodged samples.

The expected yields refer to the yield of both grain and *bhusa* that might have been obtained, had there been no lodging and were calculated with the help of (a) mean percentage losses in the yields (b) the ratio between lodged and unlodged area and (c) the actual yields under respective levels.

For determining the test weight (weight of 1000 kernels) the representative samples were drawn from the produce of each plot separately. From each sample 1000 kernels irrespective of size and appearance were counted and weighed in gms.

EXPERIMENTAL RESULTS AND DISCUSSION

The results obtained have been discussed under the following headings:—(1) Germination. (2) Lodging and (3) Test weight.

1. *Germination.*—The effects of increasing levels of nitrogen on the maximum germination expressed as a percentage of seeds own have been depicted in fig. 1. This varied between 35.35 and 39.95 of the seed sown under the different treatments. On statistical analysis of the above data, it was brought out that the above effects were not significant.

2. *Lodging.*—Table II gives the extent of lodging, its effect on acre yields and expected yields under the levels of nitrogen which induced lodging.

TABLE II.

Extent of lodging, its effect on acre yields and the expected yields under the levels of nitrogen which induced lodging.

Levels of nitrogen lbs per acre	Percentage of total area lodged	Reduction in acre yields in percentages		Expected yields (mds.) per acre	
		Grain yield	Bhusa yield	Grain yield	Bhusa yield
75	27.12	46.36	33.19	25.50	62.24
100	31.12	51.29	32.95	25.80	64.24
105	40.0	50.00	34.42	27.43	66.32

A. *Extent of lodging.*—The application of higher levels of nitrogen *i. e.*, 75 lbs and more per acre resulted in the lodging of the crop. Lodging occurred at 138th day of the life cycle *i. e.* about a fortnight after the completion of the earing of the crop.

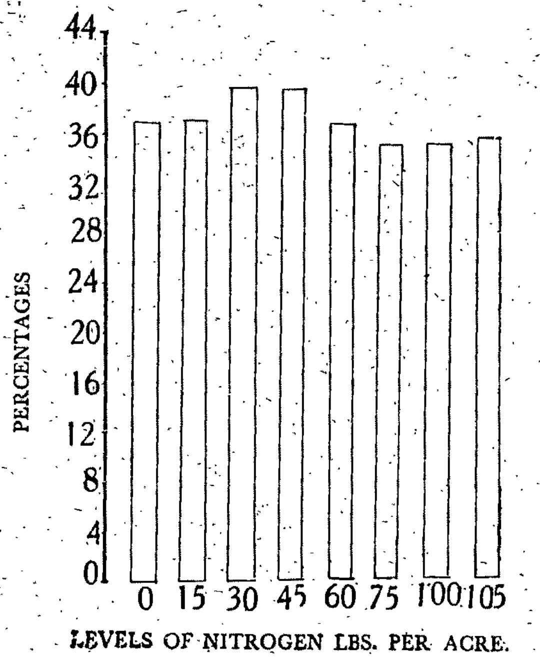
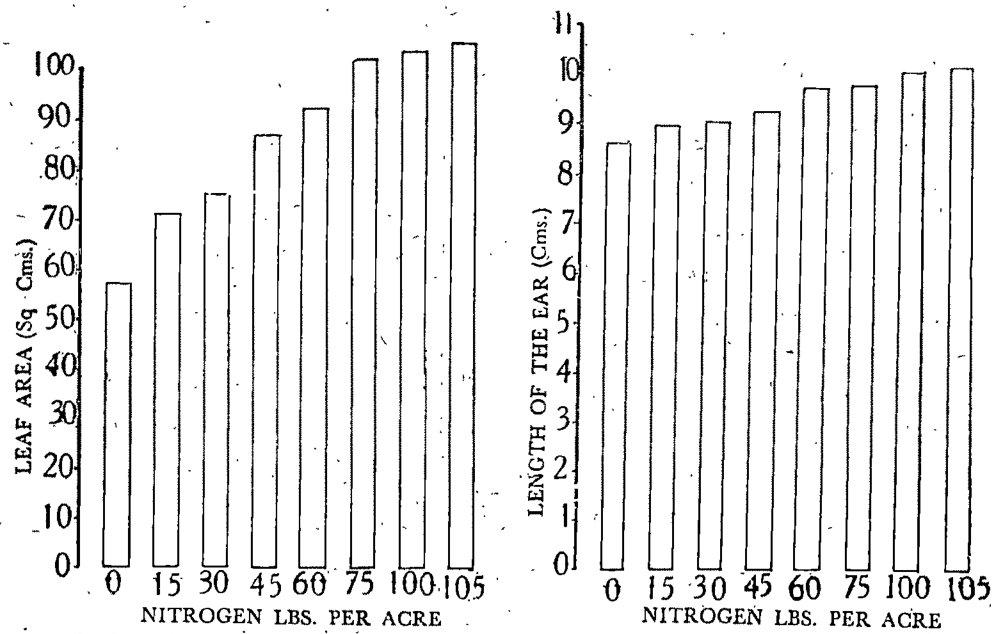


FIG. 1. Maximum germination as the percentage of seed sown under the effect of increasing levels of nitrogen.

Prior to this there was prominent easterly wind preceded by a shower of rain. It was noted that normally manured plots on the farm did not suffer lodging at all. The percentage of area lodged (Table II) under these levels increased with increasing levels of nitrogen; the mean percentages under 75,100 and 105 lbs of nitrogen were 27.12, 31.12 and 40.0 respectively.

The lodging of the crop under higher levels of nitrogen only, may be attributed to the liberal supply of nitrogen under these levels, which results in the production of more protein, which in turn utilizes most of the carbohydrates manufactured by the plant and leaves only a small portion for building the cell walls (Russell. 8). This would lead to thin cell walls and consequently to weak stems. Besides, the liberal supply of nitrogen results in the formation of large-sized leaves and ears as is clear from fig. 2 where the area of leaf and the ear length under the different levels are depicted. The increase in the aerial part of the plant due to large-sized leaves and ears on the one hand and the reduction in the strength of the stem on the other result in the lodging of the crop.

B. *Effect of lodging on acre yields.*—Due to lodging the grain yield was reduced by 46.36%, 51.29% and 50.0% and *bhusa* yield by 33.19%, 32.95% and 34.42% under 75,100 and 105 lbs of nitrogen per acre respectively (Table II). The reduction in the grain yield was more under 100 and 105 lbs of nitrogen than that under 75 lbs per acre.



LEAF AREA (Sq. Cms.) UNDER THE EFFECT OF INCREASING LEVELS OF NITROGEN.

LENGTH OF THE MAIN SHOOT EAR UN THE EFFECT OF INCREASING LEVELS O NITROGEN.

FIG. 2. Effects of increasing levels of nitrogen on leaf and shoot.

The reduction in the grain yield due to lodging may be due to the fact that the latter checked the translocation of food material to the developing kernels and thus resulted in the formation of shrivelled grains. The adverse effect of lodging on *bhusa* yield may be ascribed to (1) the reduction in photosynthesis as most of the plants were covered by others when they fell down on the ground during lodging, thus limiting the light requirements and (2) the shedding of leaves from the affected plants.

Though lodging reduced both the grain and *bhusa* yields appreciably the reduction was more severe in case of grain than that in *bhusa* yield. The mean percentages of loss in grain and *bhusa* yields were 49.21 and 33.52 respectively. This may be attributed to the fact that all the dry matter in the plants was accumulated by the time the crop lodged, while the grain formation was still going on at that time. The percentages of dry matter accumulation at different stages are depicted in fig. 3. At 138th day when lodging took place the plants had attained maximum dry weight and no further accumulation was recorded. Lodging may lead to greater sterility of spikelets and also shrivelled grains, which would account for the greater adverse effect on grain yield. The data for test weight (Table III) indicates that shrivelling of grains occurred under higher levels in which lodging occurred.

C. *Expected yields.*—The expected yields of both grain and *bhusa* under those levels of nitrogen which induced lodging have been worked out and given in table II.

The yield of wheat grain per acre would have been 25.50, 25.80, and 27.43 mds. instead of 22.35, 22.19 and 22.01 a mds. respectively and that of the bhusa would have been 62.24, 64.24 and 66.32 mds. per acre instead of 54.24, 53.59 and 55.56 mds. respectively, if the crop would have not lodged at all. It is thus indicated that the yields of both grain and bhusa would have increased with increasing levels of nitrogen even upto 105 lbs nitrogen per acre.

3. *Test weight.*—The test weights (weight of 1000 kernels) under increasing levels of nitrogen have been summarized in table III.

The statistical analysis of the data revealed that the treatment effects were significant at 1%. The calculated and table 'F' values at 1% were 8.13 and 3.10 respectively.

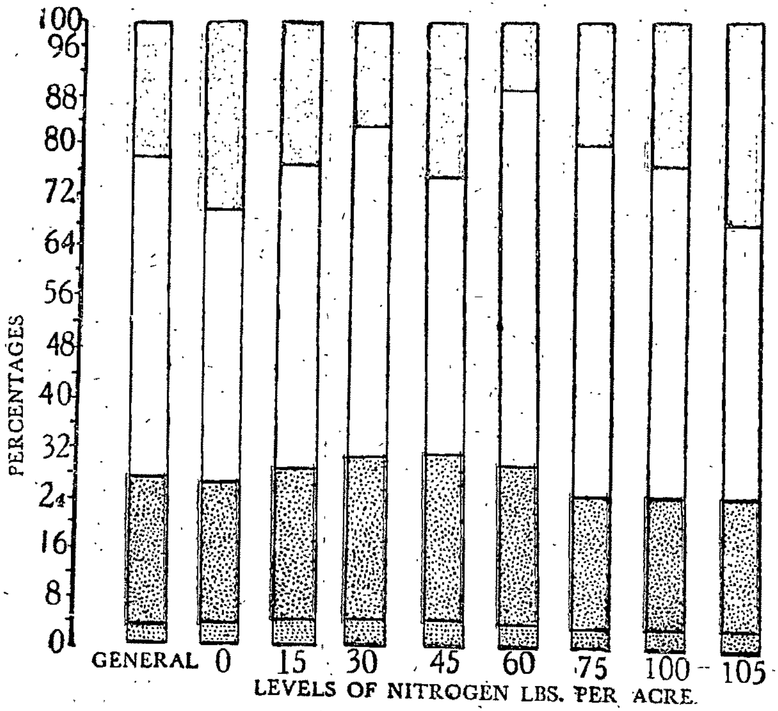


FIG. 3. Percentage of the dry matter accumulated during successive stages of life cycle under the effect of increasing levels of nitrogen Black: up to 30th day; 30th day to 60th day; red: 60th to 90th day; white: 90th to 120th day; yellow: 120th to 135th day.

TABLE III.

Effect of increasing levels of nitrogen on test weight (weight of 1000 grains).

Levels of nitrogen lbs per acre	Test weight (gms)	C. D.
0	39.43	
15	40.50	
30	41.60	
45	42.20	at 5% 1.07
60	42.90	at 1% 1.43
75	41.07	
100	40.84	
105	40.69	

The test weight increased with increasing levels of nitrogen upto 60 lbs nitrogen per acre and decreased thereafter under higher levels than this. The application of nitrogen from 15 to 105 lbs per acre increased the test weight significantly over no nitrogen. The application of 60 lbs nitrogen produced the boldest seeds and an increase in the dose beyond this level resulted in the significant decrease of test weight as compared to 60 lbs nitrogen per acre.

The increase in the test weight upto 60 lbs nitrogen per acre may be due to an increase in the amount of nitrogen available to the plants, which leads to their vigorous growth and to the development of sound kernels. The reduction in the test weight beyond 60 lbs nitrogen may be attributed to the effect of lodging, which occurring at the time of fertilization and kernel development, checked the translocation of the food material to the seeds and thus led to the formation of shrivelled grains.

SUMMARY

1. The effect of increasing levels of nitrogen (0, 15, 30, 45, 60, 75, 100 and 105 lbs nitrogen per acre) applied as ammonium sulphate with and without basal dressing of F. Y. M. at the rate of 20 lbs nitrogen per acre was studied on wheat Pb. 591 in a split plot trial under field conditions at the B. R. College experimental farm, Bichpuri, (Agra).

2. Slight variation in germination was observed under different treatments but the effects were not significant.

3. Application of 75 lbs and more of nitrogen per acre caused the wheat crop to lodge and the percentage of lodged area increased with increasing levels of nitrogen.

4. The lodging reduced the grain yield by 46.36%, 51.29% and 50.0% and the *bhusa* yield by 33.19 32.95% and 34.4% under 75, 100 and 105 lbs nitrogen per acre respectively. On the whole the grain and *bhusa* yields were reduced by 49.21% and 33.52% respectively. The reduction in the yield due to lodging was more severe in case of grain yield than that in *bhusa* yield.

5. The study of the expected yields shows that the yields of both grain and *bhusa* per acre would have increased with increasing levels of nitrogen even upto 105 lbs nitrogen per acre if there would have been no lodging of the crop under higher levels.

6. The test weight of the grains increased with increasing levels of nitrogen upto 60 lbs nitrogen per acre and decreased thereafter under higher levels than this.

CONCLUSION

The application of 75 lbs or more of nitrogen per acre to wheat results in lodging of the crop and reduces the test weight of the kernels. The accumulated effect of the adverse effects of nitrogen becomes manifest in the reduction of the final yields. Therefore, in order to get the maximum yield and to avoid the sheer wastage of the fertilizer the dose of nitrogen should not exceed 60 lbs per acre under the conditions tried in the experiment.

REFERENCES

1. COWIE, G. A. 1947. The fertilizer requirement of wheat as determined by field trials. Chem. & Industry (London) April, 1948, 211-216.
2. CROWTHER, F. TOMFORDE, A. and MAHMOUD, A. 1937. Manuring of wheat, barley, maize and rice. *Tech. Sect. Royal agric. Soc. Egypt Bull.*, No. 28.
3. GARNER, F. H. and SANDER, H. G. 1936. Investigations in crop husbandry. III Effect of time of application of ammonium sulphate to wheat. *J. agric. Sci.*, **26** : 316-327.
4. HARRIS, F. S. 1916. The irrigation of wheat. Effect of manuring on wheat. *Utah Agric. College, Expt. Sta. Rull.* No. 146.
5. MISRA, M. D. 1949. Lodging in wheat (C. 518) *Agric. & Animal Husb., U.P.*, November 1950, 31-36.
6. MURPHY, H. F. 1930. Effect of fertilizers on the yield and composition of wheat. *J. American Soc. Agron.*, **22** : 765-770.
7. RUSSELL, E. J. 1939. Fertilizers in modern Agriculture. Ministry of Agric and Fisheries Bull. No. 28.
8. RUSSELL, E. J. 1950. Soil conditions and plant growth (revised by Russell, E. W.) 8th Ed: Longamans Green and Co. London, 1950.
9. RUSSELL, E. J. & WATSON, D. J. 1940. The Rothamsted Field Experiments on the growth of wheat. *Imp. Bureau Soil Sci., Tech. Comm.* No. 40.
10. SHIVE, J. W. 1916. The effect of salt concentration on the germination of seeds. *New Jersey Expr. Sta. Rpt.*, 1916 : 455. (*Not seen in original*).

STUDY OF MYOCARDIAL DAMAGE BY INJECTION TECHNIQUE

By K. S. MATHUR, M. D., M. R. C. P.; P. N. WAHI, M. D., M. R. C. P., and D. PAL, M. D., *Heart Clinic of the Sarojini Naidu Hospital and the Department of Pathology, Medical College, Agra.*

Recently a great stress has been laid on the influence of the pattern of coronary circulation on the nature and clinical consequences of occlusion of coronary arteries. Schlesinger (12, 13, 14), has described three definitely distinctive anatomic and functional groups and has tried to explain the occurrence of coronary disease in the members of the same family on the basis of the inherited pattern of the coronary arteries.

Several investigators (6, 20) have described accessory coronary arteries, but their influence on the effective coronary circulation has only been recognized within last few years. Brink (3) has observed the presence of an accessory coronary artery supplying a large part of left ventricle and has named it as "vessel X". He attributes the infrequency of the coronary heart disease in South Africans to the presence of this vessel. Schlesinger *et al* (15) described a third coronary artery, *viz*. the conus artery, strategically placed between left descending and right coronary arteries, influencing significantly the clinical consequences of occlusion in these two vessels.

The object of the present work was to perfect the technique and to study the coronary artery pattern in Indians. It is ultimately proposed to investigate the influence of these patterns of the clinical manifestations of Coronary heart disease in this country.

REVIEW OF LITERATURE

A review of literature reveals many and diverse methods applied to the study of coronary circulation. Chirac (4) was apparently the first to investigate the effect of ligation of a coronary artery in the dog. The first detailed knowledge about the blood supply to heart was given by Von Haller (21) in 1757. He used a simple dissection method.

Swammerdamm (19) was the first to inject blood vessels with hot wax mixed with oil, which hardened in coarse vessels. Ruysch (10) used a metallic substance of secret composition, destroyed the heart muscle and was left with injected coronaries. Gross (7) used a suspension of barium sulphate in warm gelatin for injection into the coronary arteries. He fixed the heart in toto in formalin and took sterioscopic roentgenograms, instead of corroding the heart muscle. Due to overlapping of the vessels from the various planes of the heart, interpretation of such films was very difficult.

Spalteholz (18) introduced a new method of studying coronary circulation. He injected chrome yellow gelatine into both coronary arteries. The myocardium was fixed, bleached and cleared by a special process, so that it remained semitransparent while the coronary vessels were opaque. This technique retained muscle tissue for examination but was very expensive, laborious, slow and suitable for small hearts of dogs and monkeys. Thick hearts were difficult to clear.

Whitten (23) injected celluloid, using prussian blue colour for the right coronary artery, vermillion for the left coronary and silver nitrate for coronary veins. After corroding the heart muscle, he ended with casts of coronary arteries and veins. It took a week to prepare the heart, pressure had to be kept long, and if the pressure was increased vascular pattern was broken and artefacts were produced. An additional difficulty in this method was the absence of heart muscle for study of its correlation with coronary artery changes.

A significant contribution to the study of this field was made by Schlesinger (12). He discarded the idea of corrosive studies. He injected lead phosphate agar mass under a pressure of 150 mm Hg, keeping the heart in a water bath whose temperature was maintained at 37° C. He got an idea of two dimension exposure of the heart from the studies of 104 hearts made by Wenkie-an Italian in 1924 to name the branches of coronaries. Working at this, he devised a technique of unrolling the heart by a series of incisions, so that the entire arterial system could be laid out in one plane without cutting main coronary branches. Roentgenogram was then taken and a tracing of the X-ray picture made on a thin paper. Coronary arteries were then dissected and note made of any thickening, calcification, plaque, occlusion and anastomosis.

Smith and Henry (17) used neoprene, a synthetic latex for demonstration of coronary arterial system of dog by the technique advocated by Lieb (8).

Prinzmetal and his colleagues (9) in 1947 described two new methods for the study of collateral circulation of the post-mortem human hearts. In the first method they used salt suspension of erythrocytes labelled with radioactive phosphorus, which they perfused through one of the branches of left coronary artery in normal hearts and demonstrated them in the left and right ventricles. The second method consisted of the injection of glass spheres of known size through one of the coronary arteries and collected them at the opposite coronary artery, the coronary sinus and the ventricular cavities, enabling quantitative measurement of the diameter of the anastomotic channels in normal human hearts.

Salans and Tweed (11) injected natural latex as injection compound using a special apparatus and technique and unrolled the heart by Schlesinger's method. The injection mass and method of visualising coronary arteries was improved upon by Scott and his colleagues (16) who used a modified technique for unrolling the heart.

Wagner and Poindexter (22) developed a technique of injecting nylon in a series of calf hearts. The method has however not proved of use in studying the human hearts, because coronary arteries of adult human hearts could not satisfactorily withstand injection pressure of 400-500 mm Hg, necessary to produce the same effect achieved in the calf.

MATERIAL AND METHOD

The present study was conducted on 43 hearts obtained from medicolegal and pathological post-mortems. Of these, 38 were taken for detailed study, the remaining 5 were discarded due to ineffective injection.

Schlesinger's (12) technique with certain modifications was used, as it was found to be a simple, practical, quick and inexpensive method of studying the coronary circulation post-mortem. There is no overlapping of the arteries on roentgenogram—a difficulty which attended the interpretation of three dimensional specimen from a two dimensional skiagram of earlier workers. The use of masses of different colours for the two coronaries and complete dissection gives more information about the existing anastomotic communications than any of the older methods. The heart muscle is available at the end of the injection technique for the study of its correlation with coronary artery changes—a distinct advance over corrosive techniques.

The apparatus (Pl. XIII fig. 1) consists of two parts warm saline bath and mercury manometer. The warm saline bath is a 16 inches cubic bath with a capacity of 6 gallons normal saline. It is made up of brass with two glass walls. An electric immersion heater is fitted which is connected with a thermo regulator. The thermo regulator is so adjusted that it maintains a temperature of bath at 44° C. On one side is the arrangement for keeping the reservoirs (tubes) of injection mass, which are connected to the mercury manometer. At the bottom of the bath lies a metal ring with several holes which is connected to a rubber tube. This is used as a blower to keep the temperature of the bath uniform. The mercury manometer consists of two manometers connected by means of a three way stopper. The manometer is also connected with the reservoirs of the injection mass, which are kept inside the warm saline bath. The pressure in a manometer is raised by means of a rubber pump, which is exactly of the same type as is used in a blood pressure instrument.

The right and left coronary arteries are dissected carefully as they leave the aorta. A glass cannula is passed in each of them and tied securely, making sure that no branch is proximal to the tie. The thinner end is slightly raised so that it may not slip out. The warm saline bath is heated to 44° C and in order to make uniform temperature the water is shaken by means of the blower. Heart is kept hanging in this bath for 10-15 minutes. Normal saline is taken in the two reservoirs and connected to the cannula of the coronary arteries and to the manometer. Each coronary artery is washed separately with normal saline injected at 150 mm Hg pressure. Washing is complete when the return flow from the opposite coronary artery is clear.

The two reservoirs in the warm bath containing the normal saline are replaced by those containing the radiopaque lead phosphate agar mass, coloured blue and red for the left and right coronary arteries separately. Both the coronary arteries are injected simultaneously with this warm lead agar mass at 150 mm Hg pressure, until manometer reading remains constant for a few minutes without the application of any more pressure. This generally takes less than 5 minutes. The pressure in left coronary artery is now reduced to zero and maintained at 150 mm Hg in the right coronary artery; pressures are reversed after 5 to 7 minutes. This allows the mass to enter the large size anastomotic vessels. Clamps are applied to the tubes going to the coronaries. Heart is now transferred to separate bath of iced normal saline solution for about 30 minutes. The injected mass now remains solid in the vessels at room temperature.

The radiopaque lead phosphate agar mass is prepared as follows :

Solution A : Heat lead acetate 60 gms with distilled water 172 c. c. so as to dissolve it, filter through paper and allow to cool.

Solution B : Heat disodium phosphate 24 gms with distilled water 190 c.c to dissolve it, filter through paper and cool.

Now a bulb flask of 2000 c.c. capacity is taken and 1.5 gm agar placed in it. 100 c.c. of solution A is mixed with 0.06 percent phenol red and 70 c.c of solution B is added to it. To this is added 10 percent sodium hydroxide from a pipette till a pink colour is seen. Total volume of this mass is brought to 200 c.c. It is then boiled over a free flame with constant stirring until agar dissolves;

it takes about 10 minutes. While hot it is strained through several layers of gauze and stored in large sized stoppered test tubes. Just before use, this radiopaque lead phosphate agar mass is remelted by putting the tubes in boiling water and colouring dyes are added—methylene blue for left coronary and basic fuchsin for right coronary artery.

The heart is unrolled by a series of six incisions as advocated by Schlesinger (12). The first incision starts in the pulmonary artery, opening up the pulmonary valve and right ventricle on a line just to the right of the anterior interventricular sulcus and extending completely to the apex. The second incision starts in the aorta between the anterior and posterolateral cusps of the aortic valve, behind each of which is one of the cannulated coronary orifices, extending down for about 1 cm into the base of the septum and thus dividing again the pulmonary valve and the ring. The third incision begins at the inferior termination of the second incision, runs anteriorly along the base of the interventricular septum to the upper end of the anterior border of this septum, and then along the anterior border of the septum, completely to the apex, thus separating the interventricular septum anteriorly from the ventricles. The fourth incision also starts at the terminal end of the second incision, continues posteriorly along the base of the septum to the upper end of its posterior border, and then along the posterior border of this septum to the apex, thus completely removing the interventricular septum. The fifth incision starts at the middle of the free border of the anterior cusps of the mitral valve is continued through the mitral ring and aortic ring, to separate the left aortic cusp from the posterior aortic cusp. The left auricle, having been entered from below, the incision is carried parallel to the left side of interauricular septum to and through the pulmonary veins to unroll completely the left side of heart. The sixth incision starts at the junction of the anterior and medial cusps of the tricuspid valve dividing the tricuspid ring and continuing across the aortic ring to separate the right anterior aortic cusp from the posterior aortic cusp. The right auricle having been entered from below this incision is carried parallel to the right side of interauricular septum and through the superior vena caval opening to completely unroll the heart.

The heart is now X-rayed placing the pericardial surface in contact with the X-ray film and employing the following technique : Tube—XP-1, fine focus, distance 42 inches, milliamps 20, KV 48, medium cone, time one second, plain folder.

Guided by the roentgenogram of the coronary vessels kept infront on an illuminator, arteries are dissected with a fine pair of scissors. A drawing made from the X-ray appearances is marked with narrowing, calcification, occlusions and anastomoses as they are met with during dissection.

Blocks are made from the material from different parts of the myocardium and the sections studied under microscope to correlate them with the arterial changes.

OBSERVATIONS AND COMMENTS

The 38 hearts injected by modified schlesinger technique were obtained from autopsies on persons whose ages ranged between 18 and 64 years. Out of these, 26 cases were below 50 years in age.

The hearts could be grouped into three different anatomic and functional groups :—

GROUP I—Right Coronary preponderant type :

The right coronary artery supplied the whole of right ventricle, posterior half of interventricular septum plus part of the left ventricle, and from it arises the posterior descending coronary artery. 21 hearts were put in this group.

GROUP II—Balanced Circulation type :

The right coronary artery supplied the right ventricle plus the posterior half of interventricular septum. The left coronary artery supplied the left ventricle plus the anterior part of interventricular septum. 13 hearts were classified in this group.

GROUP III—Left Coronary preponderant type :

The left coronary artery suplied not only the left ventricle but also the interventricular septum and sometimes part of the right ventricle. 4 hearts fulfilled this criteria.

Blumgart *et al.* (1, 2) and Schlesinger (13) have correlated the coronary pattern to the clinical consequences of occlusion of the coronary arteries. They found unusually high incidence of occlusions and infarctions in group III hearts and these infarcts generally proved fatal. In contrast, the infarcts in hearts belonging to group II were practically always healed and two thirds of the infarcts in group I likewise healed. The low incidence of group III hearts during the present study is a favourable sign, although larger series must be studied to determine their actual frequency. Accessory arteries like conus artery, vessel X were not met with.

Twenty-eight cases had essentially normal hearts, whereas 3 additional cases had slight to moderate arteriosclerosis of coronary arteries. None of them showed any anastomosis. The size of the smallest vessel determined with the help of a micrometer in the sections taken from the hearts, showed that the injection mass had reached only upto the limits of precapillary arterioles measuring 40 micra. The absence of any anastomosis in normal hearts are in confirmity with Cohnheim and Von Schulthess Rechberg (5) concept of coronaries as 'functional end arteries'. The existence of anastomosis between the coronary arteries at the capillary level was evident from the invariable passage of saline from one artery to the other during the washing of the coronaries with saline.

4 Cases showed moderate to marked arteriosclerosis with marked narrowing of coronary arteries, whereas 2 cases had in addition occlusions of main coronary arteries. All the six cases showed intercoronary anastomosis measuring more than 40 micra in size. The development of an adequate anastomotic circulation as a compensatory mechanism consequent on slowly developed marked narrowing or occlusion of major coronary arteries accounts for absence of symptoms in such cases during life. If the anastomosis is inadequate or occlusion comes suddenly the symptoms of angina or myocardial infarction appear.

One case had moderate arteriosclerosis and a fresh thrombus was present in left circumflex artery. This heart was recovered from a Hindu male, aged 50 years, who died of shock following injury to urinary bladder. This heart belonged to the group of cases described by Blumgart and his colleagues, wherein post-operatively, in the state of shock and low blood pressure fresh coronary thrombus is sometimes precipitated. In all such cases coronary blood flow is already reduced and slowed because of narrowings.

The following table expresses the relation of Coronary artery narrowing or occlusion to the type of Anastomosis :

TABLE I. Showing relation of coronary narrowing or Occlusion to the type of anastomosis.

Case	Age & Sex	Group	Coronary arteriosclerosis	Narrowing of artery	Occlusion of artery	Type of anastomosis.
3	45 M	I	+ +	L. D.	...	Con.
7	64 M	I	+ +	R. C.	...	Conc
16	49 M	I	+ +	R. C.	...	Conc
22	40 M	I	+ + +	L. D., L. C.	...	Conc
2	50 M	I	+ + +	L. D.	L. C.	R-L Con
31	50 M	II	+ + +	R. C.	R. C.	L-R Con
29	50 M	I	+ +	L. D., L. C.	L. C.,L.D.	L-L Con

KEY TO ABBREVIATIONS:—Type of Anastomosis—L-L anastomosis between branches of Left Coronary artery. L-R branches of Right Coronary artery supplied from Left Coronary Artery. R-L branches of Left Coronary Artery entirely supplied from Right Coronary Artery Conc. branches of one or both Coronaries supplied by a mixture of blood from both the vessels.

Arteriosclerosis—Slight +, Moderate + +, Marked + + +
Narrowing or Occlusion—L. C. Left circumflex Coronary Artery
L. D. Left Descending Coronary Artery. R. C. Right Coronary Artery.

Histological examination of the sections taken from the myocardium showed old myocardial scar at the apex of the heart in case 31.

SUMMARY

The technique for the study of coronary arteries post-mortem has been described and the relevant literature reviewed.

A study of 38 injected hearts varying in age period from 18 to 60 years has been presented.

The hearts have been grouped into 3 distinctive anatomic and functional groups. Group I (right coronary preponderant type), comprised of 21 hearts, Group II (balanced circulation type), 13 hearts and Group III (left coronary preponderant type), 4 hearts.

No conus artery, vessel X or any other significant accessory vessel was detected in the present study.

The significance of the different patterns of coronary circulation as correlated with clinical consequences of occlusion has been discussed.

REFERENCE

1. BLUMGART, H. L., SCHLESINGER, M. J. and DAVIES, D. 1940. *American Heart J.*, **19** : 1.
2. BLUMGART, H. L., ZOLL, P. M. and WESSLER S. 1950. *Tr. A. Am. Physicians*, **63** : 262.
3. BRINK, A. J. 1949. *Clin. Proc.* (South Africa) **8** : 137.
4. CHIRAC, P., Quoted by Fredrick, A. W. and Thomas, J. D. 1948. "A History of Heart and Circulation." W. B. Saunders Co., Phil. & London.
5. COHNEHEIM, J. and VON SCHULTHESS RECHBERG, A. 1881. *Virchow's Archiv. Path. Anat.*, **35** : 503.
6. GRANT, J. C. B. 1944. "A Method of Anatomy". Ed. 3, Williams & Wilkins Company, Baltimore.
7. GROSS, L. 1921. "The Blood Supply to the Heart". Paul B. Hoeber, New York.
8. LIEB, E. 1940. *J. Tech. Methods*, **20** : 48.
9. PRINZMETAL, M., SIMKIN, B., BERGMAN, H. C. and KRUGER, H. W. 1947. *American Heart J.*, **33** 420.
10. RUYSCH, E., Quoted by Whitten, M. B.
11. SALANS, A. H. and TWEED, P. 1947. *American Heart J.*, **33** : 477.
12. SCHLESINGER, M. J. 1938. *America Heart J.*, **15** : 528.
13. SCHLESINGER, M. J. 1940. *Arch. Path.*, **30** : 403.
14. SCHLESINGER, M. J. 1940. "Blood, Heart and Circulation Symposium". American Association for the Advancement of Science Publication. The Science Press Printing Company, Washington D. C.
15. SCHLESINGER, M. J., Zoll, P. M. and WESSLER, S. 1949. *American Heart J.*, **38** : 823.
16. SCOTT, R. W. and YOUNG, A. F., ZOMMERMAN, H. A. and KROGH, I. 1949. *American Heart J.*, **38** : 881.
17. SMITH, J. R. and HENRY, M. J. 1945. *J. Lab. & Clin. Med.*, **30** : 462.
18. SPALTEHOLZ, W. 1924. "Die Arterian der Herzwand". S. Hirzel, Leipzing.
19. SWAMMERDAMM, H., Quoted by Salans, A. H. and Tweed P.
20. SYMMERS, W. St. Clair 1907. *J. Anat. & Physiol.*, **41** : 141.
21. VON HALLER, A. 1786. "First Lines of Physiology". (Translated by W. Cullen) Charles Elliot, Edinburgh.
22. WAGNER, A. and POINDEXTER, C. A. 1949. *American Heart J.*, **37** : 258.
23. WHITTEN, M. B. 1928. *Arch. Int. Med.*, **42** : 847.

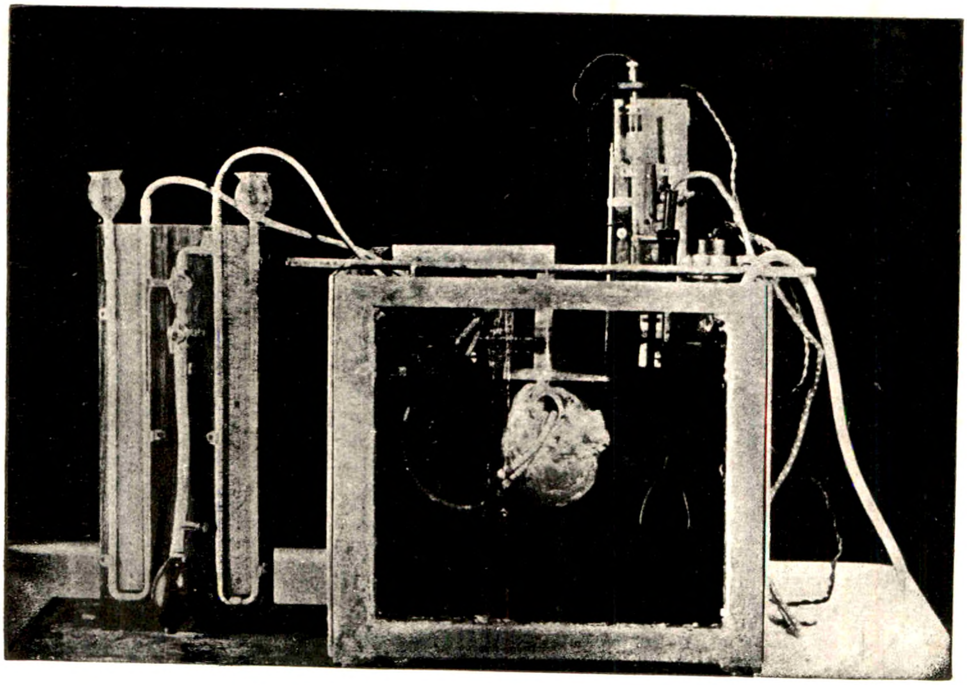


FIG. 1. Warm Saline Bath with Mercury Monometers.

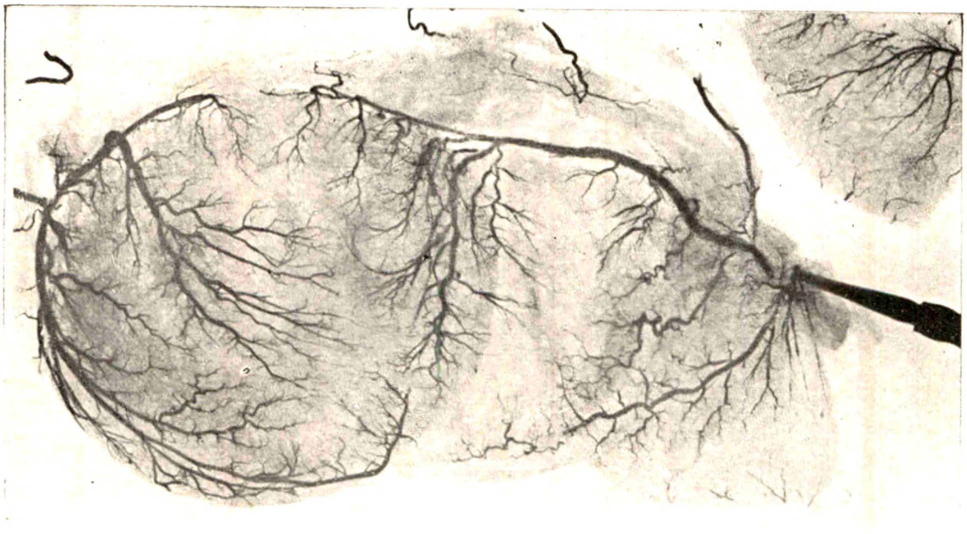


FIG. 2. Group I Heart—Right Coronary Preponderant Type.

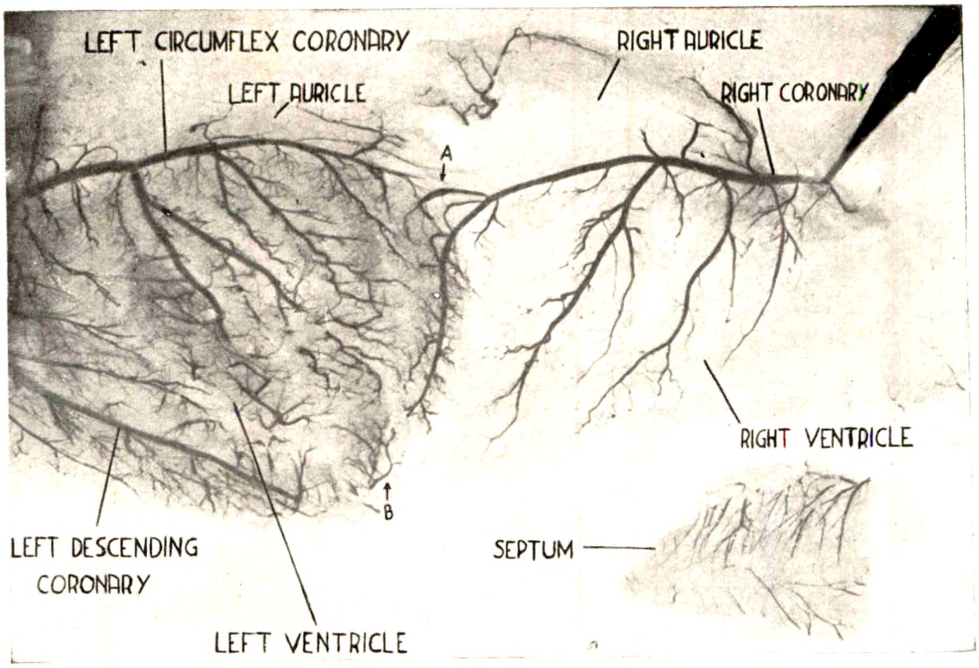


FIG. 3. Group II Heart—Balanced Circulation Type.

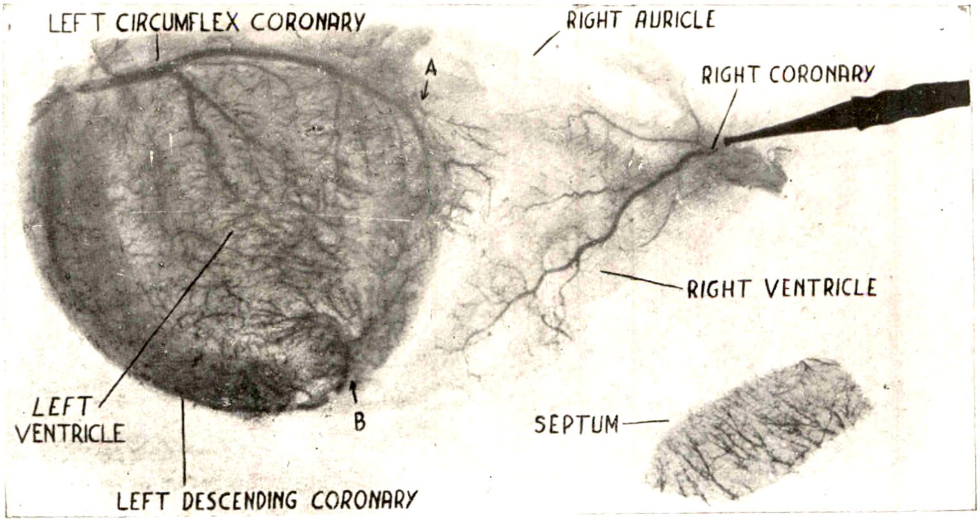


FIG. 4. Group III Heart—Left Coronary Preponderant Type.

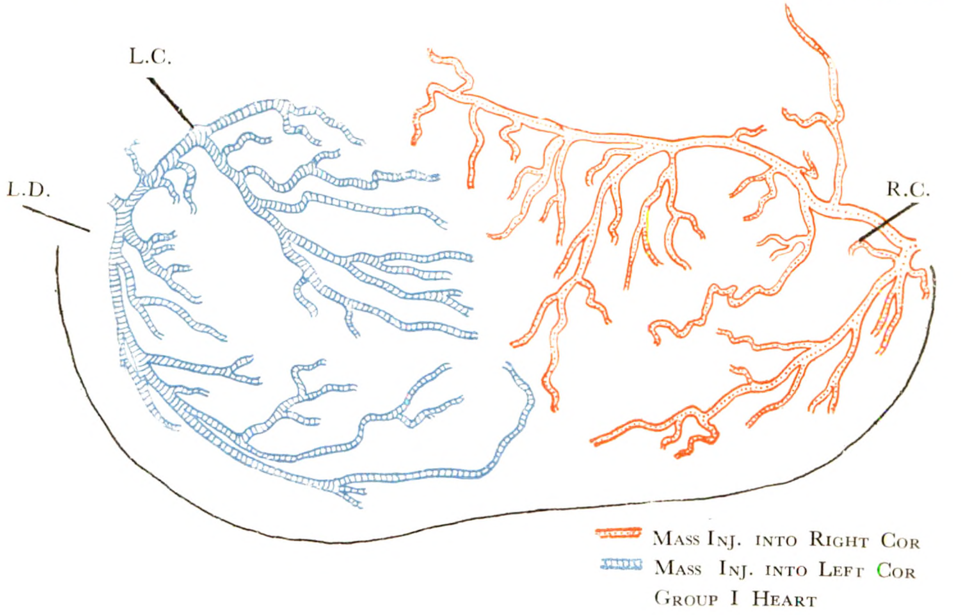


Fig. 1. Group I Heart (Right Coronary Preponderant type).

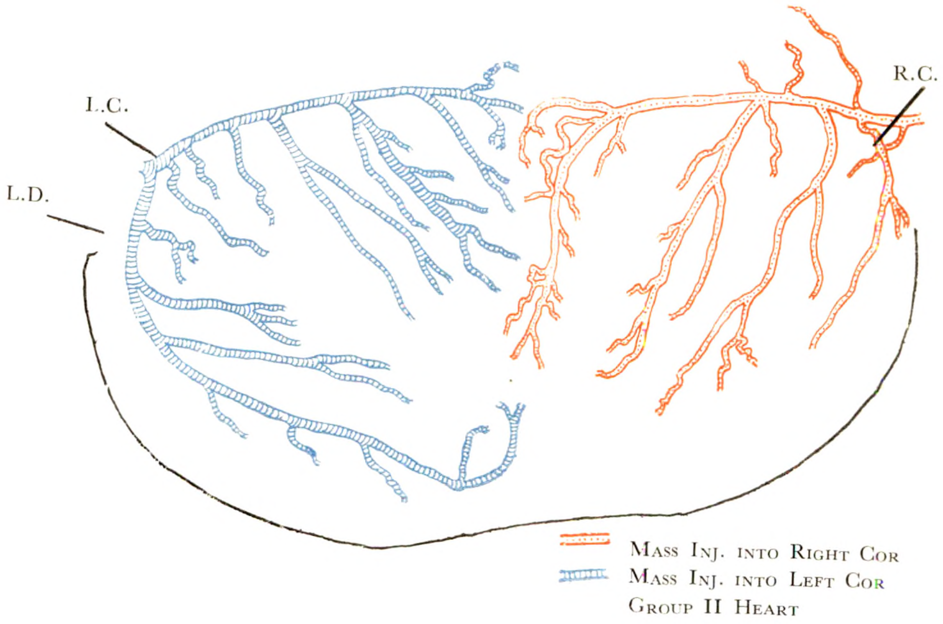
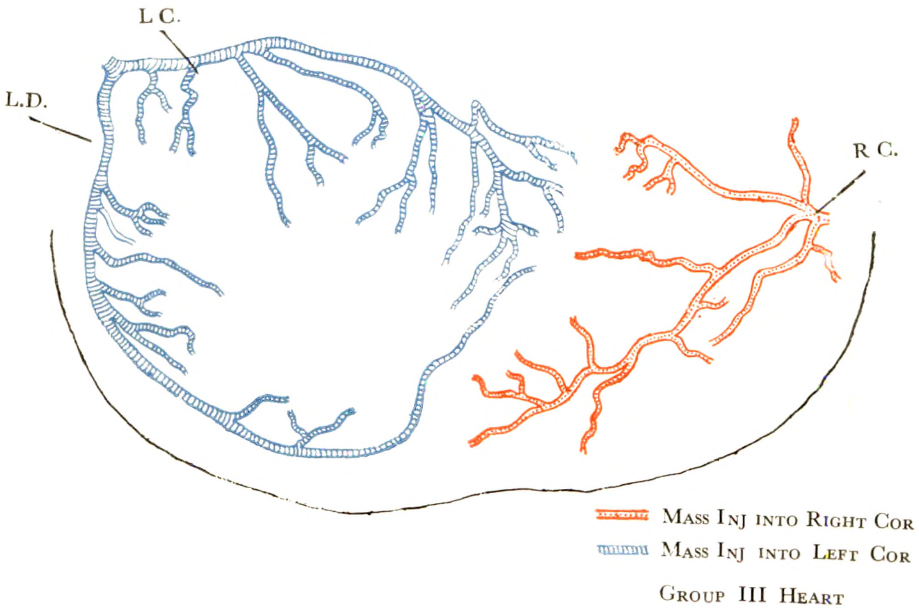


Fig. 2. Group II Heart (Balanced Circulation type).



Group III Heart (Left Coronary Preponderant type).

LIVER FUNCTION STUDIES IN VIRAL HEPATITIS*

By P. N. Wahi, M. D., M. R. C. P. (Lond.)† And M. M. Arora, M. D.‡ *From the Liver Diseases Research Unit Department of Pathology, S. N. Medical College, Agra.*

Recent epidemiological studies (11) of viral hepatitis have revealed the prevalence of this disease in this country. Subclinical phase of the disease in early stages has been reported (11). Since the specific diagnostic tests for viral hepatitis are not yet available. the use of liver function tests is one of the most useful aids to the diagnosis and management of such cases.

Use of a properly selected group of hepatic function tests in the form of composite function studies has revealed a fairly constant pattern of response in viral hepatitis and of its various stages (1). The interpretation of these results is useful both, in the diagnosis of early and mild cases of hepatic disfunction and in following the progress in convalescense.

MATERIAL AND METHODS

The present report is based on a study of 65 cases of viral hepatitis admitted to S. N. Hospital Agra during an epidemic of hepatitis in Uttar Pradesh in 1949. Liver biopsy was performed in all these cases.

The tests selected were thymol turbidity and flocculation, cephalin cholesterol flocculation, colloidal gold flocculation, bromsulphalein excretion, total and prompt serum bilirubin, urinary bilirubin and urobilinogen, total and fractional proteins and plasma prothrombin concentration and its response to vitamin K. These tests were employed in most cases as a group and the results charted in a composite function chart.

The methods adopted have been reported in previous communications (1, 10).

---

* Supported by a grant from Indian Council of Medical Research.

† Professor of Pathology, S. N. Medical College, Agra.

‡ Lecturer of Pathology, S. N. Medical College, Agra.

Liver biopsy was performed in most cases using a Vim-Silverman's needle (9). In some cases the Roholm-Iverson's needle as described by Volwiler and Jones (8) was used. The histopathological findings have been already reported (11(.

RESULTS

Thymol test.—The thymol test (turbidity and flocculation), became positive during the latter part of the preicteric stage, remained positive throughout the icteric stage and a variable period during the post icteric stage. The thymol turbidity test was positive in 83.4 percent of the cases studied. The average range of values in these positive cases was 4 to 20 units, the highest values obtained being 40 units. The following table shows the thymol turbidity in units in 54 cases of epidemic hepatitis.

TABLE I

Thymol turbidity in units in 54 cases of epidemic hepatitis.

Turbidity in Units	No. of Cases	Percentage of Cases
1-3	9	16.6
4-5	17	31.4
7.5-10	11	20.3
11-14	1	1.8
15-20	13	24.0
30-40	3	5.5

In 16.6 percent cases thymol turbidity failed to become positive. Six of these belonged to acute stage while the remaining[3] belonged to the delayed recovery group. Thymol flocculation gave positive results in 79.7 percent cases. The following table shows the degree of flocculation.

TABLE II

Thymol flocculation in 54 cases of epidemic hepatitis.

Results	No. of Cases	Percentage of Cases
0	11	20.3
+	8	14.8
++	16	29.7
+++	12	22.2
++++	7	12.9

Comparing the two tests it was found that in 6 cases thymol turbidity was positive while flocculation was negative, while the reverse was found in 2 cases. The interesting point is that these 2 cases were in the early stage.

The thymol flocculation test appears to be more sensitive in the detection of hepatic disturbance in early hepatitis. The results indicate the desirability of the routine flocculation observations as a part of the thymol turbidity test more so because Maclagan[3] has stated in his original description of the thymol turbidity test that observation for flocculation is not an essential part of it.

Colloidal gold test.—This test was positive in 76.6 percent cases of epidemic hepatitis. The results were very inconsistent as the cases with the same duration gave opposite results. Also in certain cases it was negative throughout the course of the disease or became negative at the height of the icteric stage.

Cephalin cholesterol flocculation test.—The test was positive in 76.6 percent cases after 24 and 48 hours. It usually became positive in association with the thymol test and in a few cases even earlier than turbidity. The response of the cephalin cholesterol flocculation test was however quite variable in different cases and was even negative throughout the course of the disease in some. In the present series the cephalin cholesterol flocculation test was slightly inferior to thymol test in the detection of earliest hepatic disturbance. In 29.6 percent cases of early hepatitis, Cephalin cholesterol flocculation test was negative while at the same time the thymol flocculation test was negative in 18.5 percent cases. Plasma protein studies, which were conducted simultaneously, revealed a definite relationship between positive flocculation tests and rise in plasma globulins. As facilities for electrophoretic studies of different types of globulins involved in different flocculation tests were not available, further studies of the exact mechanisms of these tests could not be done. The following table shows the degree of flocculation in 52 cases of epidemic hepatitis.

TABLE III

Cephalin cholesterol flocculation test in 52 cases of epidemic hepatitis.

Result	After 24 hours	Percentage of Cases	After 48 hours	Percentage of Cases
0	7	13.4	3	5.7
+	16	30.7	17	32.6
++	10	19.2	8	15.3
+++	18	34.6	23	44.2
++++	1	1.9	1	1.9

Bromsulphalein excretion test.—It was found to be one of the most useful procedures in the diagnosis and follow up of cases of acute epidemic hepatitis during the non-icteric stages of the disease, and in those cases which were non-icteric throughout the illness. It usually was the first test to become positive in the pre-icteric stages. In some cases it remained positive in the post icteric stages when other tests were negative. However the thymol test showed better results in the post icteric stage, in providing evidence of continued hepatic disturbance. In 7.6 percent cases of non-icteric epidemic hepatitis out of these 65 cases, this test was the first to be positive.

Total and prompt serum bilirubin and urinary bilirubin determinations showed some interesting results. Total serum bilirubin gave 94.4 percent positive results in various stages of the diseases. During the preicteric stage, the prompt-direct reacting bilirubin gave in some cases earlier positive results than total serum bilirubin. In the convalescent phase of the normal recovery group this gave positive results for larger duration than the total serum bilirubin. Urinary bilirubin determinations gave positive results in the preicteric stages before any appreciable increase in the serum and prompt direct reacting bilirubin occurred. For this reason we found this simple test as a valuable method for suggesting the diagnosis of hepatitis in early stages. However in the recovery group we found it many times negative when the total serum bilirubin was still elevated.

In 4 cases out of 65 studied, hyperbilirubinaemia was the only test positive.

Urine urobilinogen excretion test.—This test gave inconsistent results in the icteric and post icteric stages of the disease. Taking the cases at various stages, 60 percent of the cases, most of whom were in the preicteric stage, gave positive results. In some cases it was the earliest test to become positive while in others it was persistently negative. In one case out of 65 this was the only positive test.

Total plasma proteins, plasma albumin and plasma globulin.—The results were :

Hypoproteinaemia	72 percent.
Hypoalbuminaemia	98.1 percent.
Hyperglobinaemia	71.1 percent.

The following table shows the results obtained in 41 cases in whom complete total and fractional protein estimations were carried out.

TABLE IV

Table showing the degree of hypoproteinaemia, hypoalbuminaemia and hyperglobinaemia in 41 cases of epidemic hepatitis.

	Value in gms. percent	No. of Cases	Percentage of Cases
Total Proteins	4 to 5	2	4.8
	5 to 6	27	66.0
	6 to 7	12	29.2
Plasma albumin	1 to 2	10	24.3
	2 to 3	21	51.4
	3 to 4	10	24.3
Plasma globulin	1 to 2	4	9.6
	2 to 3	21	51.4
	3 to 4	15	36.4
	4 to 5	1	2.4

Determinations of the total and fractional plasma proteins were valuable indications of the severity of the process and also useful for gauging the progress of the case. These were of no particular help in the diagnosis of the nature of the lesion.

Prothrombin concentration and its response to Vitamin K.—This was found to be of considerable value. A consistently low level of prothrombin concentration that failed to respond to vitamin K was found in serious cases which mostly ended fatally. In 73 percent cases the initial prothrombin concentration was below 50 percent of normal while in 31.6 percent cases it remained below 50 percent of normal even after vitamin K injections. In only 41 percent cases in this series there was a rise above 20 percent over the initial prothrombin concentration. The following table gives the initial concentration of prothrombin and its response to vitamin K.

TABLE V

Prothrombin concentration and its response to vitamin K in 44 cases of epidemic hepatitis.

Concentration	No. of Cases	Percentage of Cases
Initial concentration below 50 percent	32	72.7
Initial concentration above 50 percent	12	27.3
Concentration above 50% after Vit. K.	30	68.4
Concentration below 50% after Vit. K.	14	31.6
Rise of upto 20% above initial concentration after Vit. K.	26	59.0
Rise above 20% above initial concentration after Vit. K.	18	41.0

This test was also found to be useful in differential diagnosis of epidemic hepatitis and obstructive jaundice.

Serial liver function studies.—Serial studies of liver function tests were carried out in a number of cases. The following table on page 9 gives the results in 4 such cases.

TABLE VI

Serial studies comparing the results of liver function tests in four patients with epidemic hepatitis.

No.	Day of disease	T. P. gms	Alb. gms	Glob gms	Fib gms	T. T. unit	T.F. Flocculation	C.G. Flocculation	C.C.F. 24 Flocculation	C.C.F. 48		S.B.	U.U. dilution
1	16	6.25	3.12	2.82	.31	5	+	+	+		+	7.6	absent
	17	—	—	—	—	5	+	+	+		+	7.4	absent
	18	—	—	—	—	5	+	+	+		+	7.4	UDU
	20	6.25	3.12	2.82	.31	5	+	0	+		+	7.6	UDU
	21	6.25	3.40	2.54	.31	5	+	0	+		+	7.0	1-30
	22	6.25	3.33	2.61	.31	5	0	0	+		+	4.5	1-10
	23	6.20	3.40	2.29	.31	4	0	0	+		+	4.8	1.10
	24	6.00	3.40	2.20	.31	4	0	0	0		+	4.3	1.10
	25	6.00	3.40	2.29	.31	3	0	0	0		+	4.5	1.20
2	26	5.95	3.35	2.38	.21	2	+	+	+	+	+	2.2	UDU
	27	5.80	3.40	2.20	.21	3	+	+	+	+	+	2.2	UDU
	28	5.90	3.40	2.19	.31	3	+	+	0		+	2.2	1-10
	29	5.90	3.40	2.20	.31	4	+	+	0		+	2.6	UDU
	30	5.90	3.40	2.19	.31	4	+	+	0		+	2.4	1-20
	31	5.96	3.36	2.30	.31	4	+	+	0		+	2.0	1.30
	32	5.88	3.32	2.15	.31	3	+	+	+		+	1.9	1-20
	33	5.98	3.42	2.26	.30	3	+	0	0		+	1.6	1-10
	34	5.96	3.42	2.23	.31	3	0	0	0		+	1.6	UDU
3	33	5.86	3.12	1.94	.62	3	0	0	0	+		3.6	1-80
	34	5.65	3.11	2.00	.50	3	0	0	+	+		3.6	1.80
	35	5.66	3.12	1.94	.62	3	0	0	+	+		3.4	1-160
	36	5.68	3.12	1.94	.62	3	0	0	+	+		3.0	1-160
	37	5.66	3.12	2.02	.52	2	0	0	+	+		2.6	1-10
	38	5.69	3.11	1.98	.60	3	0	0	+	+		2.6	1-20
	39	5.65	3.11	2.00	.54	3	0	0	+	+		1.6	1-20
	40	5.64	3.12	1.92	.60	2	0	0	+	+		1.2	1-20
	41	5.68	3.12	1.98	.58	3	0	0	+	+		1.2	UDU
	42	5.69	3.11	2.00	.58	3	0	0	+	+		1.0	UDU
4.	30	6.25	4.00	1.94	.31	1	0	0	0	+		1.2	1-40
	31	6.25	4.00	1.90	.35	1	0	0	0	+		1.4	1-40
	32	6.25	4.00	1.90	.35	1	0	0	0	+		1.4	1-10
	33	6.25	4.00	1.90	.35	1	0	0	0	+		1.0	1-30
	34	6.00	3.88	1.81	.31	1	0	0	0	+		1.0	1-10
	35	6.25	3.92	2.01	.32	1	0	0	0	+		1.0	1-10
	36	6.25	3.98	1.96	.31	1	0	0	0	+		1.0	1-10
	37	6.00	3.98	1.71	.31	1	0	0	0	+		1.0	1-10
	38	6.00	3.96	1.74	.30	1	0	0	0	+		1.0	UDU
	39	6.00	3.96	1.74	.30	1	0	0	0	+		0.8	UDU

Case I: was admitted to the hospital with complaints of anorexia, nausea, dyspepsia and pain in the right hypochondrium since 15 days. He had noted a yellow coloured urine for 15 days; the icteric tinge of the eyes was observed by him only 5 days prior to admission. Stools were clay coloured on admission. The liver was neither enlarged nor tender. The first biochemical studies of the blood were carried out on the 16th day of his illness. During the course of these studies there was an all round improvement in the symptoms and signs. Jaundice decreased and the colour of the stools returned back to normal in the last day of the serial study.

Case II: was admitted to the hospital with complaints of anorexia, high coloured urine and pain in right hypochondrium for 26 days. His stools were clay coloured and slight icterus was noted. Liver was enlarged 1" and tender. During the course of these serial studies the jaundice decreased, tenderness of the liver and clay colour of the faeces disappeared although slight icterus persisted till the 34th day of disease. His appetite, however, returned back to normal.

Case III: was admitted to the hospital with complaints of jaundice and anorexia for 33 days. He had clay coloured stools few days back but on the day of admission the colour was normal. The patient improved markedly during the course of this study.

Case IV: was admitted to the hospital with complaints of anorexia, jaundice and weakness for 1 month. During the course of these serial studies jaundice decreased markedly and appetite returned to normal.

Composite liver function studies.—The present studies have clearly demonstrated the superiority of certain tests at different stages of the disease but the results in individual cases showed sufficient inconsistency to prevent the use of one or several tests for the study of epidemic hepatitis, especially in its early or convalescent stages. With this in view, a group of liver function tests were employed and recorded in composite charts, in the manner suggested by Watson and Haffbauer[13]. The data were grouped into fulminant fatal, preicteric, acute, icteric, delayed hepatitis and chronic hepatitis. Representative charts were obtained from these groups in many instances. The data suggest the pattern of response to be expected from different stages of epidemic hepatitis.

CHART I

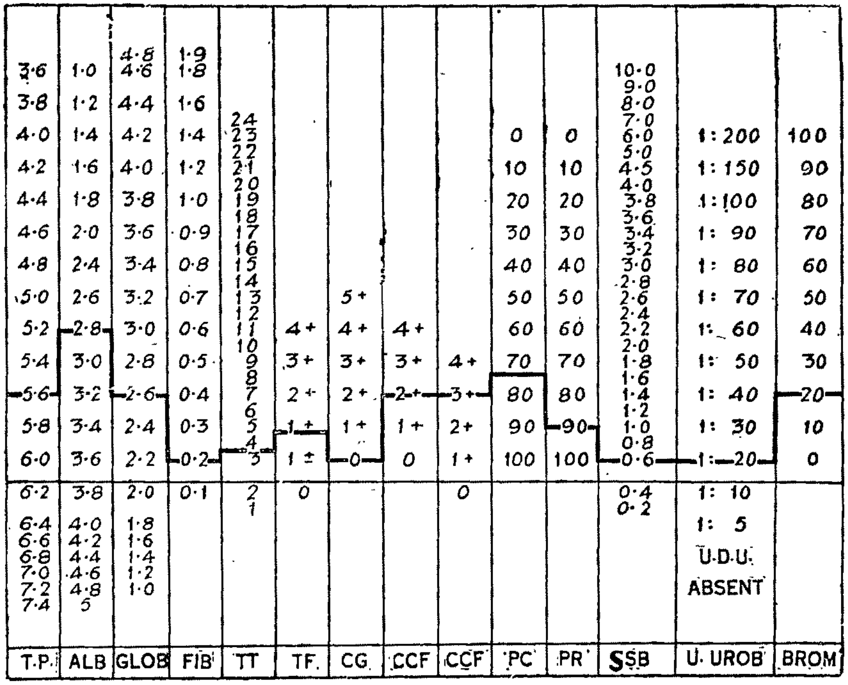


CHART I: Composite liver function studies -pattern of response in pre-icteric stage of acute epidemic hepatitis.

KEY TO COLUMN DESIGNATIONS

TP—Total plasma proteins in gms per 100 c.c.
ALB—Plasma albumin in gms per 100 c. c.
GLOB—Plasma globulin in gms per 100 c.c.
FIB—Plasma fibrinogen in gms per 100 c.c.
TT—Thymol turbidity 0 to 3 Units.
TF—Thymol flocculation 0 to 1.
CG—Colloidal gold flocculation O.
CCF—Cephalin cholesterol floc.

0 to 1 in 24 hrs.
0 to 1 in 48 hrs.

PC—Prothrombin concentration in percent of normal.
PR—Prothrombin response to Vit. K. injection in percent of normal.
SB—Total serum bilirubin in mgms per 100 c.c.
UROB—Urine urobilinogen in dilutions of urine.
BROM—Bromsulfalein, 5 mgs per kilo., in percent retained.

CHART II

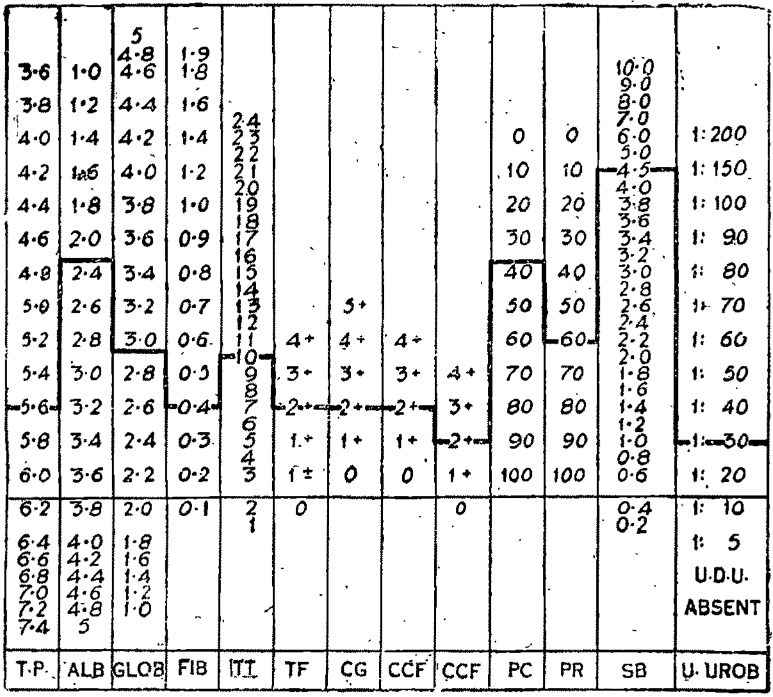


CHART II: Composite liver function studies-pattern of response in icteric stage of acute epidemic hepatitis.

CHART III

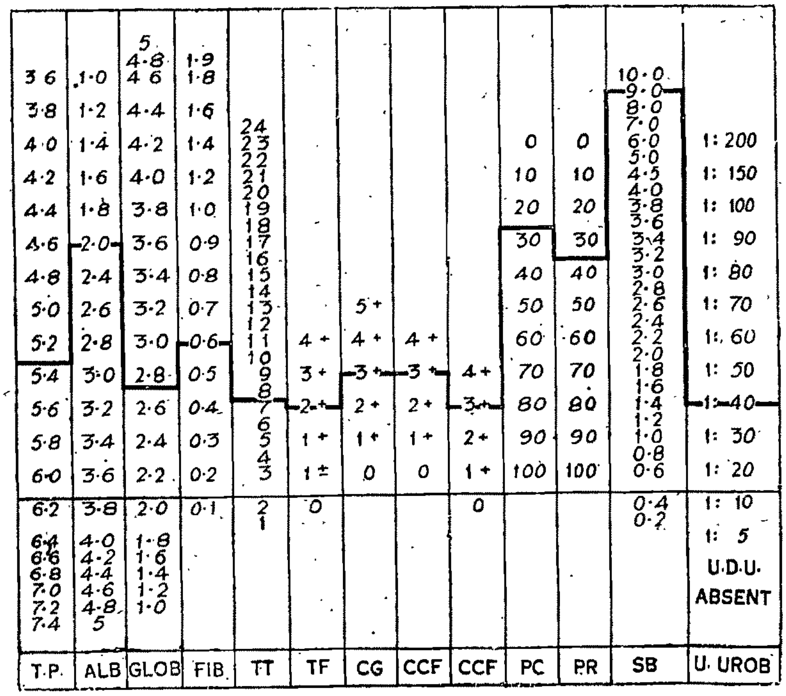


CHART III: Composite liver function studies-pattern of response in fulminant fatal type of epidemic hepatitis.

CHART IV

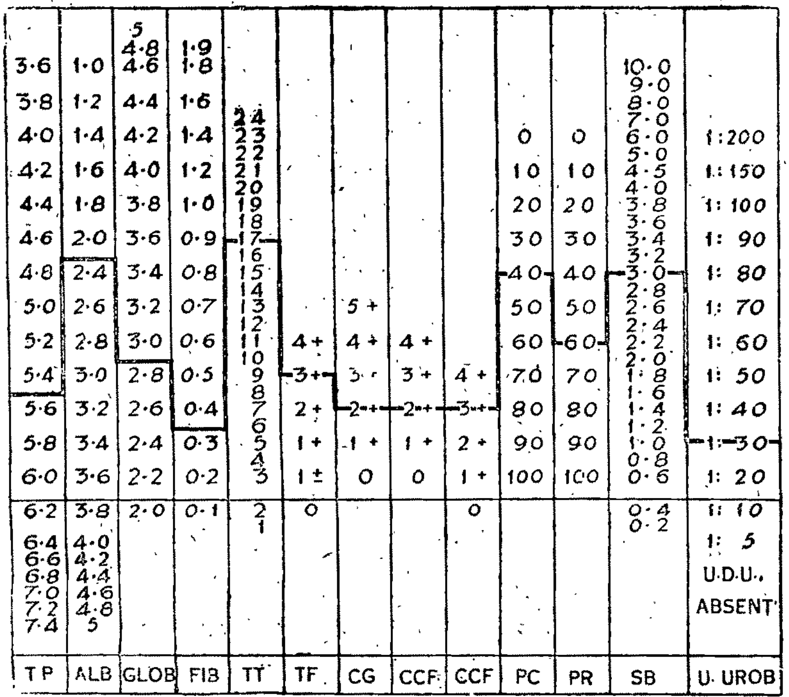


CHART IV: Composite liver function studies-pattern of response in cases of delayed recovery from epidemic hepatitis.

CHART V

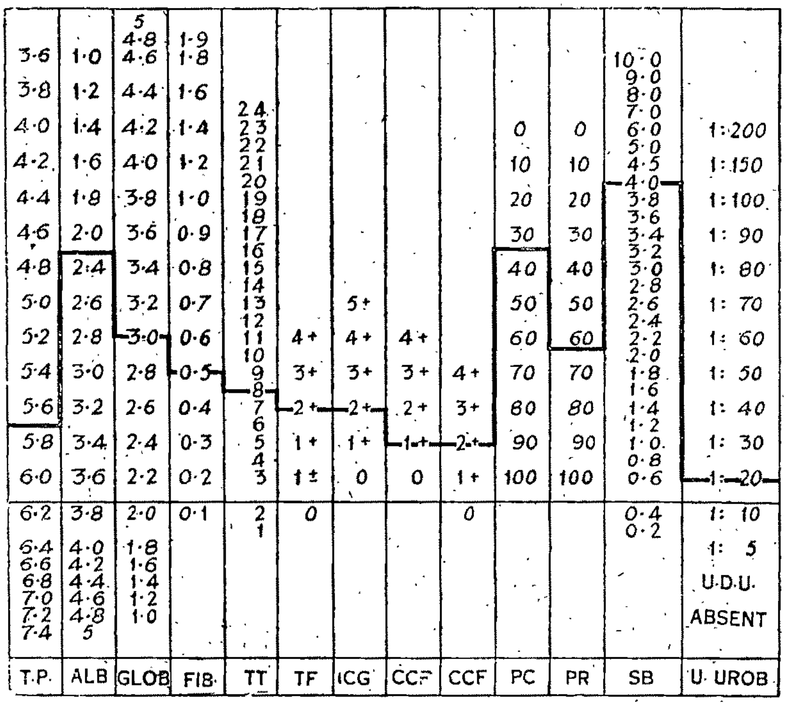


CHART V. Composite liver function studies-pattern of response in cases of chronic hepatitis.

It is however, possible that some variation from the usual pattern of response for epidemic hepatitis may occur in persons of different age group, sex, nutritional status, and in more or less serious forms of the disease.

The results of all the liver function tests in epidemic hepatitis have been analysed in table VII. This shows the correlation of positive reactions for each test with the positive reaction given by all the other tests. It is of interest to note that majority of positive tests were correspondingly matched by other positive tests.

TABLE VII

Showing number and percentage of positive reactions for each test as compared with the positive reactions given by all the other tests in 65 cases of epidemic hepatitis.

	1.	2.	3.	4.	5.	6.	7.
1. T. T.	54	48/88	47/87	49/90	50/92	30/55	0/0
2. T. F.	48/98	49	46/94	47/96	47/96	32/65	0/0
3. C. G.	47/94	46/92	50	45/90	48/96	30/60	0/0
4. C. C. F.	49/98	47/96	45/94	50	45/94	38/76	0/0
5. S. B.	50/83	47/78	48/80	45/75	60	38/63	4/6.6
6. U. U.	30/77	32/82	30/77	38/97	38/97	38	1/2.5

Numerator indicates number and denominator indicates percentage of positive reactions of test. The number at the head of the column corresponds with number of the test given at the margin. To read this table, it will be seen in column 5 that out of 65 cases studied, 60 cases showed a raised serum bilirubin, 50 out of these 60 cases had raised thymol turbidity, 47 out of these 60 had positive thymol flocculation, 48 out of these 60 had positive colloidal gold flocculation, 45 gave positive cephalin cholesterol flocculation and 38 cases gave positive urine urobilinogen readings. There were 4 cases in which only serum bilirubin gave positive results.

COMMENTS

Results of the hepatic function tests have enabled us to establish their comparative values in detection of early hepatitis and persistent hepatic disturbance during convalescence. Although the present studies have demonstrated the superiority of certain test at different stages of the disease, the results in individual cases have been so inconsistent and variable that any one or several tests cannot be used for the study of early or convalescent hepatitis.

Employment of a group of function tests is more likely to yield useful information rather than performance of single tests, especially in mild hepatic disturbance. In the present studies the results of these tests were charted in composite liver function study charts which slightly differed in jaundiced and non-jaundiced cases. Similar investigations have been carried out in other forms of liver diseases (Arora and Wahi1). In many instances fairly representative composite liver function study charts were obtained. However it must be admitted that in quite a few cases no such patterns were obtained.

It is interesting to compare the composite function study charts of epidemic hepatitis and cirrhosis of liver. Comparing the composite liver function study curves of portal cirrhosis and various stages of epidemic hepatitis it was observed that although the A/G ratio was reversed in portal cirrhosis and all stages of epidemic hepatitis except the preicteric stage (where it was normal), the associated hypoproteinaemia was more marked in fulminant epidemic hepatitis. An elevation above 5.4 gms. in the curve at the total protein column, in a case of jaundice was considered to favour the diagnosis of grave form of epidemic hepatitis. The curve of preicteric stage of epidemic hepatitis was noted to show a normal A/G ratio, a very slight rise in thymol turbidity, thymol flocculation and prothrombin response to vitamin K columns and a medium rise in the cephalin cholesterol flocculation and bromsulphalein columns.

Where the icteric stage had set in, it was noted that the A/G ratio was reversed, there was a further rise in the curve at thymol turbidity, thymol flocculation, colloidal gold flocculation, and cephalin cholesterol flocculation columns. But the most marked rise was in the curve at serum bilirubin and urine urobilinogen columns. This was more or less diagnostic of the icteric stage of epidemic hepatitis.

In those cases who had a fulminant course there was a steep rise in the serum bilirubin above 4.6 mgms. percent along with a rise in the urine urobilinogen above 1-40 dilution. This change in the curve was further associated with more rise in the other columns as compared to the curve in the icteric stage of nonfatal hepatitis. In cases with delayed recovery the most characteristic finding was a marked rise in the curve at thymol turbidity column (above 10 units). The rest was as in icteric stage of epidemic hepatitis.

Curves of chronic epidemic hepatitis and portal cirrhosis were identical except for elevated serum bilirubin in case of epidemic hepatitis. At times it was found very difficult to differentiate between the two, and in such circumstances liver biopsy was the method of choice for diagnosis.

Of the individual test our findings are almost similar to other workers. The bromsulphalein excretion, urinary bilirubin, thymol flocculation, and cephalin cholesteral flocculation were the tests which gave the earliest indication of the hepatic damage. Bromsulphalein test provided the best laboratory test for the diagnosis in the early stages. It was normal in Neefe's[6] 3 cases and a few cases of Flood and James[2].

Urinary bilirubin was detected in the majority of cases in preicteric stages and at this stage the serum bilirubin levels were within normal range. This simple test was thus found to be a very valuable procedure in giving a clue to the diagnosis of epidemic hepatitis in its preicteric phase. The results in the posticteric stage were very variable with this test. Similarly it was noted that prompt direct reacting bilirubin was frequently increased before there was any increase in the total serum bilirubin. Similar observation has also been made by Neefe et al[7].

The cephalin cholesterol flocculation was positive in 76.6 percent cases of the entire series. This test was found to be slightly inferior to thymol test in the detection of earliest hepatic distrubance. The test was noted to remain positive throughout the icteric stage of epidemic hepatitis in 75 percent of these with positive results.

The thymol turbidity and flocculation test was found to be positive in 83.4 and 79.7 percent cases respectively. These tests were found to be positive in all those cases who had active parenchymal damage, as also observed by Maizles[5] and Maclagan[3,4]. As already observed the thymol turbidity test failed to become positive in the acute phase in 9 cases.

Determinations of the total and fractional plasma proteins, were found useful in following the course of the disease.

Prothrombin activity measurements revealed that in fulminant fatal type of epidemic hepatitis the response to vitamin K injection was very poor and most of the total cases had a initial concentration less than 50 percent and a response of less than 20 percent. The test was found useful in the differential diagnosis of surgical and medical jaundice. Results of colloidal gold test were very inconsistent, as cases in different stages gave similar results.

The data presented here serve to emphasise the long recognised fact that a group of tests must be used to exclude or establish the presence of mild to moderate hepatic disturbances. The use of the composite liver function study, with the results depicted in the graphic form could be of considerable help in the analysis of hepatic disease. Unfortunately, on account of large number of tests involved in the study, an elaborate liver function chart, like the ones presented in this paper, is neither applicable to any large number of individuals nor is it applicable to frequent serial usages. We find that liver function studies undertaken according to schedules (1). One, two, three are more likely to practical application. The details of these have already been given in a previous communication (1). In the follow up of hepatitis, it is more informative to use a liver function score. (12) and (1).

SUMMARY

Results of studies of liver function in 65 cases of viral hepatitis during an epidemic in Uttar Pradesh are reported.

The findings of individual tests and their relative values in the diagnosis of the various stages of viral hepatitis are given.

The compositive liver function curves, charting the group of tests employed, are given and their value in diagnosis of viral heptitis and its various stages is discussed. It is suggested that these are too elaborate to be adopted as a routine, and the modified schedules may be morepractical.

REFERENCES

1. ARORA, M. M., and WAHI, P. N. 1953. Composite Liver Function Studies. *Indian J. med. Sci.*, **7** : 391.
2. FLOOD, C. A., and JAMES, E. M. 1947. *Gastroenterology*, **8** : 175.
3. MACLAGAN, N. F. 1944. *Nature*, **154** : 670.
4. MACLAGAN, N. F. 1944. (a) *B. M. J.*, **2** : 363.
   1944. (b) *Brit. J. Exp. Path.*, **25** : 234.
   1947. (c) *B. M. J.*, **2** : 197.
5. MAIZLES, M. 1946. *Lancet*, **2** : 451.
6. NEEFE, J. R. 1946. *Gastroenterology*, **7** : 1.
7. NEEFE, J. R., STOKES, J., RHEINHOLD, J. G., and LUKENS, F. D. W. 1944. *J. Clin. Investigationsital.*, **23** : 836.
8. VOLWILER, W., & JONES, C. M. 1947. *New England J. Med.*, **237** : 651.
9. WAHI, P. N. 1946. *Indian med. Gaz.*, **81** : 130.
10. (a) WAHI, P. N., & ARORA, M. M. 1952. *Indian J. Med. Sci.*, **6** : 165.
    (b) WAHI, P. N., & Arora, M. M. 1952. *Indian J. Med. Sci.*, **6** : 235.
11. WAHI, P. N., & ARORA, M. M. 1953. *New England J. Med.*, **12** : 451.
12. WATSON, C. J. 1945. Conference on Liver Injury, Josiah Macy Jr. Foundation, New York, March.
13. WATSON, C. J., & HOFFBANCE, F. W. 1946. *Ann. Indian Med.*, **25** : 195.

SEXUAL DIMORPHISM AND EVERSION OF THE HEMIPENES IN *UROMASTIX HARDWICKII* GRAY*

By JAGDISH CHANDRA AGRAWAL, M. SC., *Department of Zoology, Agra College, Agra.*

Dayal (1931) claimed that there was "complete absence of a penis" in *Uromastix hardwickii*. At the kind suggestion of Prof. B. C. Mahendra I investigated the hemipenes and sexual dimorphism of this species.

Uromastix, a fairly common herbivorous and frugivorous terresterial lizard from the semi-deserts of North Africa and South-Western Asia, lives in burrows. Specimens of both sexes were collected from Deeg, Bandiqui, Bharatpur and suburbs of Delhi, the largest individual measuring 178 mm. from snout to vent.

SEXUAL DIMORPHISM

Smith (1935) mentions sexual differences in the tint and colour pattern in *Uromastix asmussi* (Strauch), but none in *Uromastix hardwickii*. Referring to the external prominences due to the penes, he says that they "are seldom very distinct, and the sexing of a lizard from the external appearance is not to be relied upon". In order to distinguish the sexes in Sauria, according to him "a longitudinal incision through the skin over the seat of the swelling" is necessary. A careful examination of individuals of *Uromastix hardwickii*, however, shows that they can be sexed readily and correctly on the basis of external characters, although these are not sometimes distinct in preserved material. The males in the living condition bear dark reticulations on the back against a general background of grey, while the females have them against a pale brownish tint. The males are darker, with a somewhat more prominent pattern. It is possible, however, that such a difference might be due to various other factors—for example, to local variations in population, pigmentary response, individual variations or differences in physiological activity. The femoro-pre-anal pores are more prominent in the male than in the female, (Plate XVII, figs. 1 and 2) .The males, at least in the breeding season, have a pair of distinct rounded nodule-like swellings (Plate XVII, fig. 2) due to hemipenes on either side of the mid-ventral line on the base of the tail. In females these swellings are scarcely, if at all, prominent. There are also semi-distinct ridges and furrows at the anterior border of this region.

---

*Part of an M. Sc. thesis approved by the University of Agra in 1952 in lieu of one theory paper.

THE HEMIPENES

The hemipenes are a pair of eversible sac-like organs lodged on either side of the mid-longitudinal line on the ventral side of the tail immediately below the skin. They are muscular and have each a thin elongated retractile muscle extending from the hinder end of the penes to the proximal caudal vertebrac. According to McCann (1946) these muscles "extend the whole length of the tail". In *Uromastix hardwickii*, however, they run backwards only a short distance, an inch or so in a full-grown specimen, to be inserted on the caudal vertebrae.

Each hemipenis of *Uromastix hardwickii*, when everted, is a sub-cylindrical organ divisible into a stalk-like *pedicel* and a distal *head*. The pedicel is of the same dimension throughout the greater part of its length. The hinder border of the cloaca extends in the form of a fold almost to the distal end of the hemipenis, terminating there in a sort of depression. Between this fold and the body of the pedicel lies a groove, the *sulcus*, which serves to conduct the sperm during copulation. The head bears no spines and has two or three grooves separated by low ridges on its upper surface.

In order to understand the mode of eversion of the hemipenes I scrutinized carefully the details of the procedure necessary for effecting the eversion artificially both in the living and freshly killed specimens. If a male is held by its trunk in the left hand so that its ventral surface faces the experimenter and the tail is siezed at its base near the cloaca by the right hand, pressure on the hemipenial swellings by the right thumb and twisting the tail gently towards the right would evert the right hemipenes ;

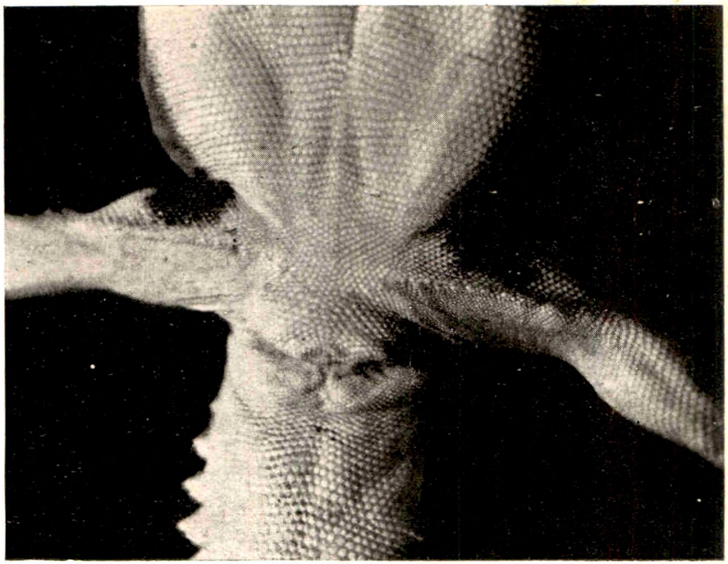


FIG. 1. Ventral view of a female *Uromastix hardwickii.*

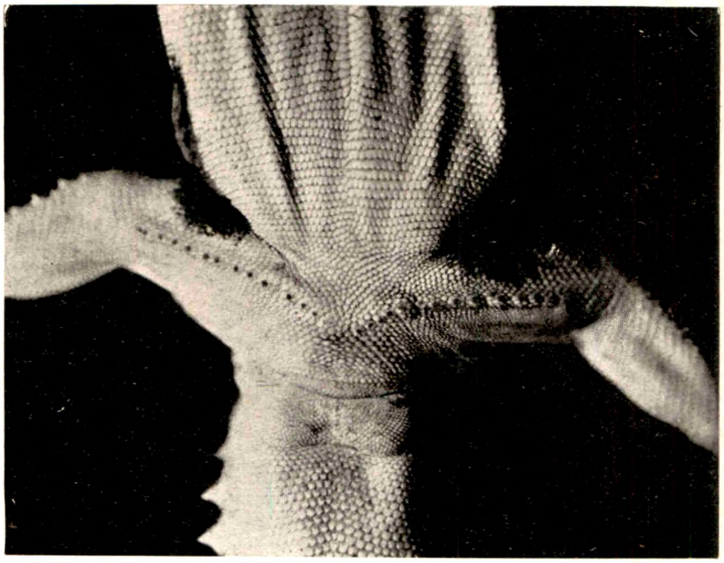


FIG. 2. Ventral view of a male *Uromastix hardwickii.*

and *vice versa* in case of the left hemipenis. This seems to indicate that the eversion of the hemipenes in nature is entirely due to muscular activity, producing a similar pressure and twist. During mating the male twists its tail to the right or the left so as to bring its cloacal aperture and ventral surface of the tail obliquely up so as to face the corresponding surface of the female. This twisting of the caudal region seems to be effected in conjnuction with the contraction of the caudal muscles surrounding the hemipenes, thus producing the requisite pressure on the organ and everting it. The retroversion of the hemipenes is effected by the long retractile muscle, described above.

REFERENCES

1. DAYAL, J. 1931. "On the Urinogenital system of the lizard, *Uromastix hIrdwtckii* (Gray)." Indian Science Congress, Nagpur Session, *Abstractse of papers, Zoology Section*. Calcutta. Asiatic Society of Bengal, 1931.

2. MCCANN, C. 1946 "The Hemipenis in Reptiles." *J. Bombay Nat. Hist. Soc.*, **46** (2) : 348-373

THE ANATOMY OF THE HEMIPENES IN *UROMASTIX HARDWICKII* GRAY.

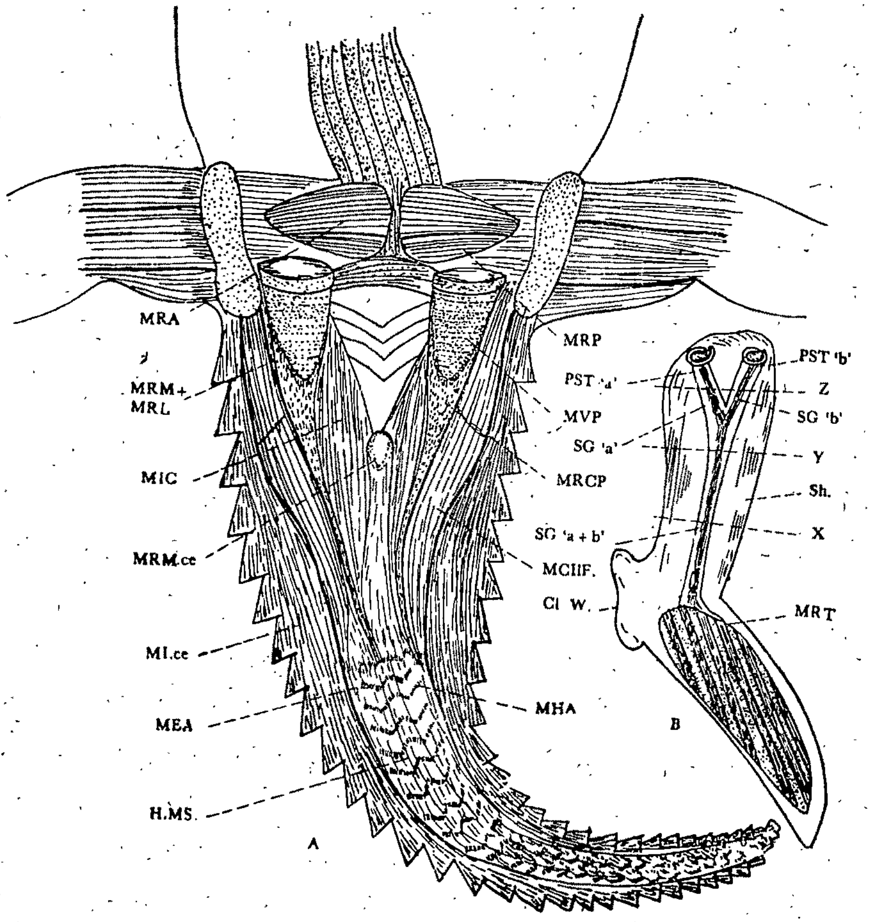
By TRILOK MAJUPURIA, M. SC., *Madhya Bharat Government Research Scholar, Gwalior.*

The present note deals with the structure of the hemipenes of *Uromastix hardwickii*, a spiny-tailed lizard common in the semi-arid regions of North India. McCann (7), who has given a general account of the hemipenes in a number of Indian reptiles, makes no reference to this species. Agarwala (1) describes the sexual dimorphism and gross anatomy of the hemipenes of this speci s. Specimens for the study were obtained from Dholpur and Bharatpur states. In addition to dissections, I have also studied serial sections of the entire tail of the male with the hemipenes *in situ*, of on everted hemipenis separated from the associated parts, and of the uneverted hemipenis.

I take this opportunity of recording my grateful thanks to the Madhya Bharat Government for financial assistance. I am grateful to Prof. B. C. Mahendra, Agra College, for suggesting the problem, to Drs. Aikat and Mogha, G.R. Medical College, Gwalior, for facilities for work and to Prof. M. B. Mirza, Muslim University, Aligarh, for the loan of literature.

In the retracted condition, the hemipenes are stowed, as in other lizards, in the basal part of tail ventral to the hypaxonic set of caudal musculature immediately behind the posterior margin of the vent. They are hollow and distally taper to a point to form a pair of post-anal swellings just behind the vent. Each hemipenis (Text-fig. 1) lies underneath the *vaginalis penis* muscle of its side, laterad of the *m. ischio-caudalis*. Anteriorly it is confluent with the dorsal wall of the proctodeum, while posteriorly it extends into a tapering *retractor penis* muscle, which passing backwards for a little distance is inserted on a caudal vertebra.

In the everted condition, the hemipenes protrude ventro-laterally out of the vent as fairly turgid intromittent organs. They are seen to consist of a distal part or head and a proximal basal stalk. In this condition the urodaeal orifice lies in close apposition to the base of the hemipenis. The latter bears a longitudinal groove along the stalk ending in



Text Fig. 1

Text—Fig. 1. A: Dissection of the caudal muscles associated wiih the hemipenes and cloaca (semi-diagrammatic). MCIEF—M. Caudo-ilio femoralis ; MEA—M. Epiaxonic ; MHA—M. Hypaxonic ; MIC—M. Ischio caudalis ; HMS—Horizontal Myoseptum ; MRA—M. Relevator Anterior; MRM—MRL—M. Relevator medialis—M. Relevator lateralis; MRP—M. Relevator posterior ; MRt.P—M. Retractor penis ; MRmcl.—M. Retractor Medialis, cloaclis, MVP—M. Vaginalis penis. B. Dissection of an everted hemipenis of *Uromastix hardwickii.*- Cl.W—cloacal wall; PST 'a', PST 'b'—Penis Subtract 'a', Penis Subtract 'b', SH—Sheath;—SG 'a', SG 'b', SG 'a—b'—eminal Groove 'a' Seminal Groove 'b', Seminal 'a—b' ; X,Y,Z.—Three planes of sections shown in Text- Fig 2 B,C,D.

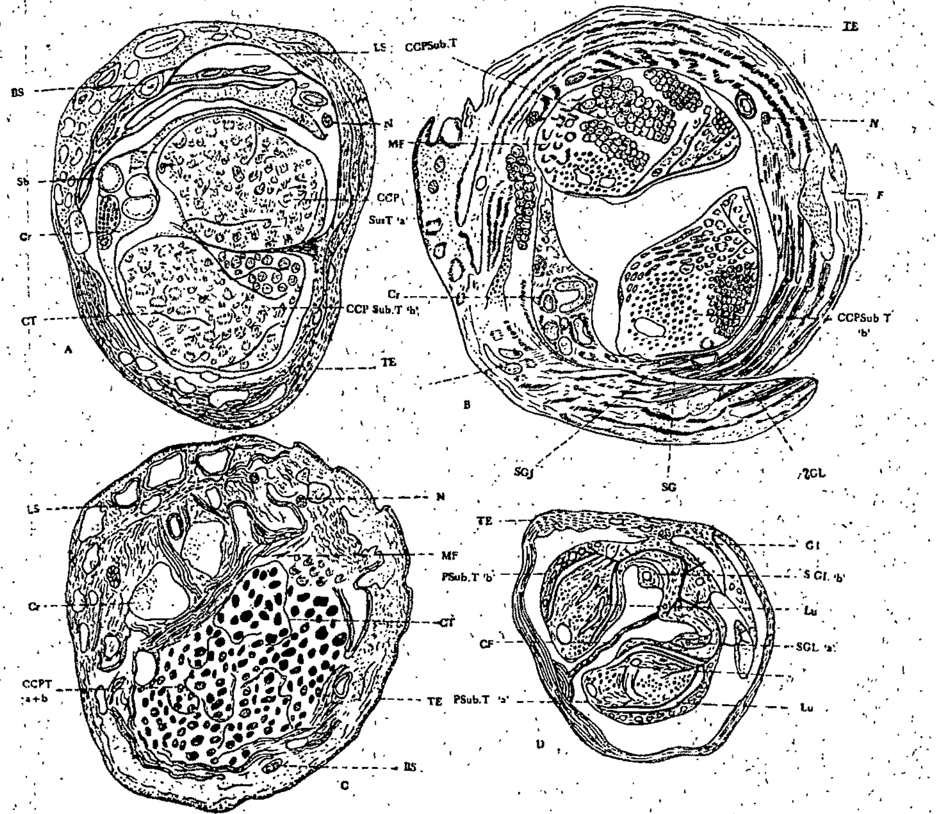
a depression on the head, which is bounded by a pair of terminal lobes provided with narrow slender crests. A fibrous penis-tract from the stalk bifurcates into two subtracts, which lie in the terminal lobes and bear knob like ciliated structures at their extremities. The seminal groove runs parallel to the penis-tract and divides into two subgrooves corresponding to the penis subtracts mentioned above.

The seminal fluid flows from the urodaeal orifice into the basal elevation of the hemipenis, passes along the seminal groove and discharges into the cloaca of the female from the terminal depression of the penis head.

In transverse sections of the uneverted hemipenis, separated from the other associated structures (text. fig. 2), the external layer of the connective tissue (tunic externa) appears to have irregular folds. It is connected dorsally with a cavernose tissue and with the two penis subtracts. From this tunia externa projects distally a cavernose fold, between the two subtracts, the latter appearing in sections as bulbous structures. Surrounding the penis subtracts, is the epithelium which comes to lie outermost when the hemipenes are everted. In the penis subtracts are a number of fairly large irregular spaces. In sections through the posterior region of the hemipenis *in situ* inside the tail, the fibres of the *m. retractor penis* are very abundant and compact.

In sections through the basal region of the everted hemipenis the corpus cavernosum, is an irregular but single structure traversed by many fibres of connective tissue, but towards the distal end it divides into two bodies forming the corpora cavernosa of the two penis subtracts. These abound in lacunae and blood vessels. Sections through the head of an everted hemipenis show a narrow seminal groove, which is bounded by a projecting edge, the sperm-lip and overlies an internal crest-like mass, formed by connective tissue and abounding in blood spaces.

Of the muscles connected with the hemipenes, the following three are particularly important :—(a) *M.ischio-caudalis* (b) *M. retractor penis* and (c) *M. vaginalis penis*. The *M. ischiocaudalis* arises from the haemal arches of the caudal vertebrae and is inserted by a tendon on the posterior margin of the ischium. The *M. retractor penis* forms the investment-like tubular outer coat of the



Text Fig. 2

Text—fig. 2. D. Transverse section of the uneverted hemipenis of *Urom astix hardwickii* BS—Blood Space ; MF—Muscle Fibre; CF—Cavernose Fold ; GI—Groove Inlet; Lu—Lumen, P. Sub T 'a', P Sub T. 'b'—Penis Subtract 'a' Penis Subtract SGL 'a'-SGL 'b'—Seminal groove lip 'a' ; Seminal groove lip 'b' ; TE—Tunicexterna. C. Transverse section of an everted hemipenis of *Uromastix hardwickii* passing through the plane 'x' shown in Text Fig. 2. BS—Blood space; CT—connective tissue ; Cr—crest, CCPT a × b—Corpus cavernosum Penis tract a × b, MF—Muscle Fibre ; LS—Lymph space ; N—Nerve ; TE—Tunic externa. A. Transverse section of an everted hemipenis of *Uromnstix hardwickii*, passing through the plane 'y' CCP sub T 'a'—corpus cavernosum penis subtract 'b' ;(other abbreviations as in previous figures. D. Transverse section of the head of a hemipenis passing through the plane 'z' CCP sub T 'a' —corpus cavernosum penis subtract 'a' ; CC.P Sub. 'b'—corpus cavernosum penis subtract b, F—Fold, SG—seminal groove ; SGL—seminal groove lip ; SGL—seminal Junction.

hemipenis. It is overlaid in its origin underneath the pelvic girdle by a broad plate-like cloacal muscle, the *m. relevator anterior*, and extends backwards as a hollow elongated cone, lateral and adjacent to the ischiocaudalis muscle, ending in the form of an attenuated fibrous extension, which passes back obliquely upwards and inwards between the *ischio-caudalis* and *caudo-iliofemoralis* muscles to be inserted on the ventral aspect of a caudal vertebra. The *m. vaginalis penis* lies over the anterior part of the hemipenis, being coherent with the ventral epithelium of the tail. It generally separates from the underlying muscles when the skin is removed in dissections.

REFERENCES

1. AGARWALA, J. C. 1954. Sexual dimorphism and eversion of the hemipenes in *Uromastix hardwickii* Gray. *Agra University J. Res.*, **3**: 535
2. BOAS, J. E. V. 1891. Zur Morphologie der Begattungsorgane der amnioter Wirbeltiere. *Morph. Jahrb.*
3. COPE, E. D. 1896. Hemipenes of the Sauria. *Proc. Acad. Sci. Nat. Philadelphia.*
4. DEYSACH, L. J. 1939. The comparative morphology of the erectile tissue of the penis with special emphasis on the probable mechanism of erection. *American J. Anat.*, **64** III—131.
5. GADOW, H. 1886. Cloaca and copulatory organs of the Amniota. *Phil. Trans. Roy. Soc. London* (B) 178.
6. HOFFMAN, C. 1890. Reptilien Bronn's Klassen und Ordn.
7. MC CANN, C. 1946. The Hemipenis Reptiles. *J. Bombay Nat. Hist. Soc.*, **46** : 2.
8. SMITH, MALCOLM 1935. "Sauria"—Fauna Brit. India.
9. TONUTTI, E. 1934. Einheitliche Ableitung der Wirbeltierekopulationsorgane. *Verh. Anat. Ges.* Jena. 42.
10. UNTERHOSSEL, P. 1902. Kloaka und Phallus der Eidechsen und Schlangen. *Morph. Jahrb.* 30.
11. WIEDERSHEIM. R. 1907. Comparative Anatomy of Vertebrates translated by W. N. Parker, London.
12, WOPKE, K. 1931 "Die Kloake und die Begattungsorgan der männlichen Zanneidechse (Lacerta agilis-L.)" *Jena. Z. Naturw.*, **65** (2) : 275-318.

ON THE LOWER SYSTEMATIC CATEGORIES AND THEIR SIGNIFICANCE IN TAXONOMY AND EVOLUTION*

By M. L. ROONWAL, M. SC., PH. D. (CANTAB.), F. N. I., F. Z. S. I.
Forest Entomologist, Forest Research Institute, Dehra Dun

(With one Text-figure)

CONTENTS

Page
I—Introduction 545
II—The Lower Systematic Categories ... 547
(a) General 547
(b) Lower categories of the first order ... 548
(c) Lower categories of the second order ... 550
(d) Conclusions 555
III—Summary 556
IV—References 556

I. INTRODUCTION

Modern systematics may be said to begin with the 18th century Swedish botanist, Linnaeus (or Linné), who first introduced the "binomial system" of nomenclature in his books *Systema Naturae*, *Species Plantarum* and others. According to this system, each distinct species is written with two names—the first the generic and the second the specific epithet,—thus : *Felis tigris* for the tiger, *Felis pardus* for the leopard, and so on. The 10th edition (1758) of the *Systema Naturae* of Linnaeus has been recognized internationally as the starting point for animal names. For plant names various dates, beginning with Linnaeus's *Species Plantarum* (1753) and ending with Hedwig's *Species Muscorum* (1901), have been agreed upon as the starting points for different groups of plants.

Linnaeus and the early authorities gave a specific name to almost every clearly distinguishable variety and did not take into account, to any appreciable extent, either interspecific relationships or intraspecific variations. That indeed was to be expected in an age dominated by the idea of the 'fixity of species'. To the biologists of those days there was, in fact, no 'species problem' at all !

---

*Based largely on the author's Presidential Address (*vide* Roonwal, 1949 *a*).

The spell of this 'closed-shell' outlook was broken by the great French biologist, Lamarck. As a result of life-long observation and in the teeth of bitter opposition, he boldly set forth his great idea of 'evolution', namely, that there is a great deal of individual variation found in species, and that the not infrequent difficulty of distinguishing one form or species from a closely allied one leads us to the conclusion that species are continually changing, *i.e.*, evolving, and are far from being fixed. This revolutionary concept was first presented by Lamarck in his famous book *Philosophie Zoologique* (1809) and later on elaborated in his seven great volumes on the lower Inveretbrates (1815-1822). Thus, for the first time Lamarck created, so to speak, the 'species-problem'. How deep and correct was Lamarck's understanding of the true nature of the species-problem can be judged from the following passages from *Phil. Zool.*, Chapter 3, which, although written nearly a century and half ago, sound in all respects as if they were written by a modern taxonomist and evolutionist

> "It is not a futile purpose to decide definitely what we mean by the so-called *species* among living bodies, and to enquire if it is tree that species are of absolute constancy, as old as nature, and have all existed from the beginning just as we see them today; or if, as a result of changes in their environment, albeit extremely slowly, they have not in course of time changed their characters and shape....
>
> "Any collection of like individuals which were produced by others similar to themselves is called a species.
>
> "This definition is exact; for every individual possessing life always resembles very closely those from which it sprang; but to this definition is added the allegation that the individuals composing a species never vary in their specific characters, and consequently that species have an absolute contancy in nature.
>
> "It is just this allegation that I propose to attack, since clear proofs drawn from observation show that it is ill-founded.
>
> "The almost universally received belief is that living bodies constitute species distinguished from one another by unchangeable characteristics, and that the existence of these species is as old as nature herself. This belief became established at a time when no sufficient observation had been taken, and when natural science was still almost negligible. It is continually being discredited for those who have seen much, who have long watched nature, and who have consulted with profit the collections of our museums.
>
> "Moreover, all those who are much occupied with the study of natural history know that naturalists now find it extremely difficult to decide what objects should be regarded as species.
>
> "They are in fact not aware that species have really only a constancy relative to the duration of the conditions in which are placed the individuals composing it ; nor that some of these individuals have varied, and constitute races which shade gradually into some other

> neighbouring species. Hence naturalists come to arbitrary decisions about individuals observed in various countries and diverse conditions, sometimes calling them varieties and sometimes species. The work connected with the determination of species therefore becomes daily more difficult, that is to say, more complicated and confused."

Lamarck stated further on that the production of fertile hybrids between species is "by itself sufficient gradually to create varieties, which then become races, and in course of time constitute what we call species".

As a result of the recognition of variations, certain subspecific groups came to be recognizsed. Taxonomic classification has, as a consequence, tended to be more and more detailed. In the present account I shall discuss briefly the relative status of the various kinds of intraspecific categories which may collectively and conveniently be called the 'Lower Systematic Categories' to distinguish them from categories of full specific rank and above.

II. THE LOWER SYSTEMATIC CATEGORIES

(*a*) GENERAL

It is necessary to emphasise at the outset that the 'species' concept is essentially and fundamentally a population concept. That is to say, a species is a collection or *population* of like individuals. Since the individuals vary, how much alike they should be to one another in order to be called one species (as distinguishable from a similar population of like individuals which constitute *another* species), is a matter which we will now consider. A large number of intraspecific terms have been introduced in the literature, and we will consider here only the more important and significant ones.

In the older systematics, when almost every sufficiently distinguishable form was separated as a species, the natural relationships of these forms were obscured and a false picture obtained. With the recognition of 'subspecies' and their consequent grouping into natural 'species-groups', the species-concept became better comprehensible both within the species-group itself and between the different species-groups. This conception of form-groups or form-circles (*Formenkreis*) was first given by the German ornithologist, Kleinschmidt (1900, 1930), and later greatly extended and clarified in a series of penetrating analyses by another German authority, Rensch (1929-1947), to whom modern taxonomy thus owes a large debt of gratitude.

In discussing the lower systematic categories it would, I believe, be convenient to distinguish two groups (Table 1) which I may term, thus:

(*i*) Lower Categories of the First Order.—These are subject to the International Rules of taxonomic (nomenclative) procedure, *e.g.*, rules of priority, etc. They include such terms as subspecies, race, form, forma paramorph and variety.

(*ii*) Lower Categories of the Second Order.—These are *not* subject to the International Rules of taxonomic procedure, but are none the less, real population-groups, being discrete entities in nature. They include such terms as clines, clones, pure lines, strain, breed, biological race, physiological race, genotypes, ecotypes, ecogenotypes, micro-subspecies, phases, mutants, aberrations, and so on.

(*b*) LOWER CATEGORIES OF THE FIRST ORDER

The term *subspecies* as used today has a definite geographical connotation, and in this respect, as well as in the fact that it is subject to the rules of taxonomic procedure (*e.g.*, the rule of priority of names, etc.), it resembles a full species from which, however, it differs in many important respects. Thus, for example, whereas, two species may inhabit the same geographical area, two subspecies of a species as a rule do not do so. Exceptions are known, but in nearly every case which has been properly analysed it has been found that the two subspecies inhabit different ecological niches (such as different levels on a mountain slope, and so on), and do not usually come into competitive contact with each other. A trinominal system of nomenclature fits such a group of subspecies very well. The terms race, form (or forma) and variety have been in common usage in systematic literature and are, in actual practice, almost pure synonyms of subspecies. The term variety, however, has been used in diverse senses to denote not merely intraspecific differences at the subspecies level but also individual aberrations, and it is desirable to abandon it altogether in systematic usage. Huxley (1939*b*) has proposed that a noncommittal term, *paramorph*, be used to denote all variants from the normal. Well marked intra-group variants may then be designated as aberrations, mutants, phases or modifications, as the case may be.

The recognition of the subspecific levels has brought about a change of the specific and generic outlook, and the following conceptions, which are now gaining acceptance among systematists, may be mentioned :—

Subspecies.—Forms which show geographical replacement (*vide supra*), but are usually connected by intergradation. If isolated, they are not sufficiently differentiated to deserve a specific rank.

Monotypic species (Rensch's *Art*).—Species which are not differentiated into subspecies.

Polytypic species (Rensch's *Formenkreis**).—Species which are differentiated into two or more subspecies.

Supraspecies.—Groups of forms or subspecies which show geographical replacement, but some of them show a sufficient degree of differentiation certainly or probably to merit specific ranks. This category occupies an intermediate position between polytypic species and 'geographical subgenera' (*vide infra*).

Geographical subgenus (or *enus*) (Rensch's *Artenkreis*).—Groups of related forms, each group clearly meriting species rank but showing geographical replacement to a degree which makes it certain that they have arisen by geographical differentiation.

The *genus geographicum* or geographical genus is, thus, a natural unit. It differs from the term 'genus' of common usage which is an artificial concept, being composed of a number of geographical genera, in much the same natural way as a species is composed of a number of subspecies. The *genus geographicum* is the highest taxonomic category with, like the species, a real existence in nature, further categories from genera (of common usage) upward being artificial concepts.

---

*This differs from the *Formenkreis* of Kleinschmidt (1900—1930).

(*c*) LOWER CATEGORIES OF THE SECOND ORDER (Table 1)

(*i*) *General*

When we come to even lower systematic categories which are not subject to rules of taxonomic or nomenclative procedure, we enter a territory where there are no straight, well laid roads but, instead, a great variety of complicated pathways whose mystery takes a great deal of unravelling. Before one begins to understand the meaning of these zigzag pathways, and even to suspect their existence, a considerable amount of intensive search must be made within the narrow limits of a single species or subspecies. In this respects, every species seems to be a law unto itself, and comparisons derived even from closely allied species frequently do not hold good. The field here becomes intimately interlinked with genetics, and it may be stated at once that the understanding of all types of variation lies within the general framework of Mendelian or particulate heredity—that, at any rate, has been the experience of the last half-century of genetical and evolutionary research. Attempts to elucidate genetical and evolutionary phenomena on any other basis have proved unsatisfactory. A rather different note has, however, been sounded by the Russian botanist, Lysenko (1943), in his highly controversial book *Heredity and its Variability*. It is a difficult book to follow, but the main points that Lysenko seems to emphasize are these : First, that the "heredity" or "nature" of an organism is changed not by seemingly causeless "gene mutations" as advocated by the "Mendelian-Morganian geneticists", but more or less directly by the influence of the environment, a point of view which is hardly distinguishable from that propounded long ago by Lamarck (*vide supra*). Secondly, that the vehicles for the transmission of the hereditary material are not the "fictitious" genes but the entire living material of plants and animals.

(ii) *Clines, clones, pure lines, etc.*

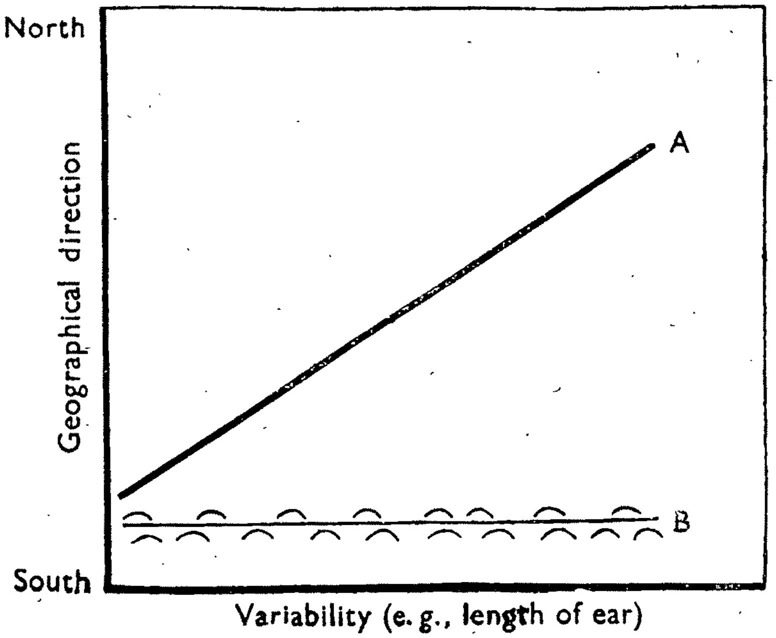
One of the most outstanding events in the field of intraspecific variability was the brilliant analysis of Johannsen (1903) resulting in his discovery of genotypically *pure lines* ("reine Linien") in beans. Such pure lines have since been found to be widely prevalent in plants, and have also been demonstrated among animals in several Protozoa (Jennings, 1908, 1909 ; Jollos, 1921) where they are produced asexually (by apomyxis) and are termed *clones*, as discussed below.

Recently, Huxley (1938, *et seq.*) has invented the term *cline* for indicating "a geographical gradient in phenotypic characters" which is frequently found within a species extending over a large geographical area. These character-gradients were in fact recognized long ago, and are exemplified in such '*laws*' as those of Bergmann, Gloger, Allen, and others (*vide* Rensch,) 1929-1947 ; Carter, 1951). Thus, there may be a north-south cline as regards the length of ears in a mammal, or an east-west cline as regards the length of bill in a bird, and so on—the length gradually increasing as we proceed from one direction to another. For example, many species of Indian pigeons and owls (Roonwal, 1940, 1941, 1949*e* ; and Roonwal & Nath, 1949*a*) and other birds decrease in size as we go south, the largest individuals of a species occurring in the Himalayas, the smallest in Travancore and Ceylon. Similarly, there is a cline of increasing human skin colour as we move from the poles towards the tropics. Huxley (1939*a*) has distinguished several categories of clines, and Haldane (1948) has recently calculated the progress of a cline under a set of certain ideal conditions.

The comparative significance of clines and clones in intraspecific variation is of some importance and may be discussed briefly. Johannsen had applied the term 'pure line' to a small population, within a species, of individuals derived from a single seed by self-fertilization.* Individuals thus derived are so similar and so genetically pure that they maintain their purity (as regards variation) through successive generations in spite of stringent selection; change can, however occur by mutation. This characteristic was formulated by Hagedoorn & Hagedoorn (1921) into a Law of Johannsen which stated that "the nature of these genes does not admit of qualitative variation". Thus, pure lines and clones imply an essential homogeneity of such small groups and, therefore, a certain *discontinuity* between such groups within a species. Pure lines and clones have been regarded by some authors as 'elementary species'. Clines, on the other hand, denote, as far as it is possible to judge, essentially a continuous variability-gradient (uniform, unidirectionally-progressing distribution of variance) without the presence of a number, however large, of more or less discontinuous groups of clones. Furthermore, whereas clines denote geographical and ecotypic (*i.e.*, environment-conditioned) variation running parallel, for example, with decreasing temperatures as happens when we move away from the equator (*cf.* ecotypes, *infra*), the variation as between two clones is non-ecotypic : clone-variation is genotypic. The variability which exists *within* each clone, however, may possibly be ecotypic.

---

*Both apomyxis and self-fertilization ultimately produce groups of genotypically identical individuals. They, however, differ in this respect that whereas prolonged selfing may produce an almost completely homozygous pure line, the clones produced by apomyxis (which is asexual) retain whatever heterozygosis may be present in the ancestors.



Text-fig. 1.—Diagrammatic representation of (A) the *cline*-type and (B) the *clone*-type of intraspecific variability. Within each clone the variability is represented by a crescent; it fluctuates very closely around its own characteristic mean which tends to remain constant. A large number of clones in a species-population may produce a *false* impression of continuous variation (represented by the line B in the figure). ((*After* Roonwal, 1949*a*.)

Clone-variability in a species, if not suitably analysed, gives an impression of continuity (believed to be a characteristic of cline-variability) in what is known to be fundamentally discontinuous variation, and this point needs emphasis (Text-fig. 1).

Whereas we know the precise mechanism of the production of the clone-type of variability, we are still almost wholly in the dark regarding the mechanism by which the cline-type of variability is produced. Although Huxley conceives clines as purely phenotypic, it is possible that even the cline-type of continuance of variance may, on suitable genetical analysis, prove to be essentially discontinuous, being produced by the varying proportions of gene-frequencies in different populations. This possibility is heightened if a particular unit character, in respect of which a cline exists, is represented in the genotype by multiple factors. The larger the number of factors, however, the more difficult becomes their analysis. So far, such analyses of clines are not available.

Hagedoorn & Hagedoorn (1921, pp. 213-215) have drawn a distinction between pure lines and clones. According to them, in both these groups selection can theoretically result in a change, but the mechanism of change is different. In clones change occurs by vegetative segregation of the gene material during reproduction; in pure lines it occurs by loss-mutation (loss of gene.)

(*iii*) *Genotypes*, *ecotypes*, *ecogenotypes*, *etc.*

The term *genotype* refers to the genetic constitution of an organism derived from its forefathers; it thus differs from the *phenotype* which is the outward expression of the genotype after reacting with the environment. A genotype will not, as a rule, change with the environment. It is difficult to distinguish between a genotype and a clone. When, however, genotypes do change with the environment, tending to reach a certain stability wherever that particular environment occurs in the range of a species, they are said to produce *ecotypes*.

The term *ecotype* was introduced by the Swedish botanist, Turesson (1922-1931), in plants to designate distinctive 'habitat types' which resulted from the "genotypical response of the species population to a definite habitat"; genotypes unfitted for that habitat are sieved out by selection. Ecotypes of this nature have also been found among animals, *e. g.*, in the rodent *Peromyscus* *maniculatus* (Dice, 1940). Ecotypic differentiation may be either regional or strictly local. The former type generally occurs in species having a wide latitudinal or altitudinal distribution, and is usually climate-conditioned, but the range of variation is not generally continuous in the direction of a gradual change of climate (*cf.* clines, *supra*). There are formed, instead, small population-groups each with its own climatic latitude of tolerance. Ecotypes may coincide with geographically differentiated subspecies, the latter being distinguishable by not possessing the above mentioned characteristics. The term *micro-subspecies* has been applied to such cases where, for example, the form of a mollusc from one lake differs from that of a neighbouring lake in the same area; or, a species of a sedentary grasshopper may show diverse forms in differently coloured areas of sandy or rocky ground. It is hardly possible to distinguish such micro-subspecific categories from ecotypes, and the two terms may prove to be synonymous, the former having a general usage for plants, the latter for animals.

Population-groups where genotypes and ecotypes coincide are designated by the compound term *ecogenotypes*; examples are known from the fly *Drosophila.*

(*iv*) *Phases*

In locusts Uvarov (1921, 1928) discovered a peculiar type of variation which was correlated with population density. In swarming years locusts, *e. g. Locusta migratoria* L., *Schistocerca gregaria* (Forsk.) and other species, are morphologically distinct from those in the non-swarming years when they live in comparatively low numbers in their permanent breeding grounds. The two extreme forms (which were formerly regarded as distinct species) were termed *phases* by Uvarov—one the *gregaria* or swarming phase, the other the *solitaria* or non-swarming phase. The two extremes are connected by a series of intermediates. The existence of the phases has been confirmed by many workers as a result of extensive experiments. The phases have now also been shown to occur in some moths (Lepidoptera).

In the Desert Locust, *Schistocerca gregaria* (Forskal), the writer has shown (Roonwal, 1936-1954) that *within* the *solitaria* phase itself there occur a considerable number of variable but easily distinguishable groups. These groups are best characterised by the difference in the number of eye-stripes and the following forms are distinguishable (also *vide* Roonwal, 1954) :—

(A) The *gregaria* phase group.—Only one type of individual, *viz.*, the 6-eye-striped type, with heavy eye pigmentation in the interstripes.

(B) The *solitaria* phase groups.—Eyes striped, but interstripes not heavily pigmented. *Four* distinct types of individuals occur—with 5, 6, 7 and 8 eye-stripes. Of these, the 6- and 7-striped individuals are common, the other two types occurring very rarely.

The importance of this type of non-phasic variation in the Desert Locust, especially its bearing on evolutionary problems, has been discussed in detail by Roonwal (1954).

(*d*) CONCLUSIONS

In conclusion, we may summarize the various important types of intraspecific variations. These are listed in Table 1.

TABLE 1.—The more important intraspecific systematic categories.

Subject to rules of taxonomic (nomenclative) procedure.	*Not subject to rules of taxonomic (nomenclative) procedure.*
Subspecies	Cline
Race	Clone, pure line
Form, Forma	Strain
Paramorph	Breed
Variety	Biological race
	Physiological race
	Genotype* (in genetic sense)
	Ecotype
	Ecogenotype
	Other population-groups, *e. g.*
	Micro-subspecies, etc.
	Phase (*e.g.*, in locusts; and armyworm moths)
	Mutants, Aberrations, Modifications

---

* The term 'genotype' is here used in the genetic sense. It denotes a population whose individuals have the same genetic constitution and, therefore, the same potential morphological characteristics. In taxonomic usage, 'genotype' means that species which is typically characteristic of a generic name and which has been so designated by the author of that genus.

III. Summary

1. The evolutionary significance of the various species concepts is discussed, with particular reference to the systematic categories lower than the species.

2. Among the 'lower systematic categories', two main groups are recognized : (*i*) Lower categories of the first order. They are subject to the rules of taxonomic (nomenclative) procedure, and include such categories as subspecies, race, form, formal varieties, etc. (*ii*) Lower categories of the second order. They are *not* subject to the rules of taxonomic procedure, and include such categories as clines, clones, pure lines, strain, breed, biological race, physiological race, genotypes, ecotypes, ecogenotypes, micro-subspecies, phases, and so on.

IV. References

Carter, G. S. 1951. *Animal Evolution. A Study of Recent Views of Its Causes.* xv+368 pp.—London (Sidgwick & Jackson).

Darwin, C. 1859. *The Origin of Species by Means of Natural Selection, etc.*—London.

Dice, L. R. 1940. Ecologic and genetic variability within species of *Peromyscus.—Amer. Nat.* Lancaster (Pa.), **74** : 212-221.

Dobzhansky, T. 1941. *Genetics and the Origin of Species.* (2nd ed.) 446 pp.—New York.

Gloger, C. W. L. 1833. *Das Abändern der Vogel durch Einfulss des Klimas. Nach zoologischen, zunächst von den Europäschen Landvögeln entnommenen Beobachtungen dargestellt, mit den entsprechenden Erfahrungen bei den Europäschen Säugethiere vergleichen, usw.* xxix+159 pp.—Breslau.

Gregor J. W. 1944. The ecotype.—*Biol. Rev.*, Cambridge, **19** : 20-30.

Hagedoorn, A. L. and Hagedoorn, A. C. 1921. *The Relative Value of the Processes Causing Evolution.*—The Hague (Martinus Nijhoff).

Haldane, J. B. S. 1932. *The Causes of Evolution.* 235 pp.—London and New York.

Haldane, J. B. S. 1948. The theory of a cline.—*J. Genet.*, Cambridge, **48** (3) : 277-284

Huxley, J. 1938. Clines : - An auxiliary taxonomic principle.— *Nature,* London, **142** 219

Huxley, J. 1939*a*. Clines. An auxiliary method in taxonomy.—*Bijdr. Dierkd.* (Konik. Zool. Genoostsch., Amsterdam), Leiden, **27** [1939] : 491-520.

Huxley, J. 1939*b*. Remarks on a discussion on 'subspecies' and 'varieties'.—*Proc. Linn. Soc. Lond.* London, Sess. **151** (1938-39) (2) : 105-114.

Huxley, J. (Ed. by) 1940. *The New Systematics.*—Oxford.

Huxley, J. 1942. *Evolution : The Modern Synthesis.*—London.

Jennings, H. S. 1908. Heredity, variation and evolution in the Protozoa, I. The fate of new structural characters in *Paramaecium* in connection with the problem of the inheritance of acquired characters in unicellular organisms.—*J. exp. Zool.*, Philadelphia, **5** : 577-632.

Jennings, H. S. 1909. Heredity, variation and evolution in the Protozoa II. Heredity and variation of size and form in *Paramaecium*, with studies of growth, environmental action and selection.—*Proc. Amer. philos. Soc.*, Philadelphia, **47** [1908] : 393-546.

Johannsen, W. 1903. *Über Erblichkeit in Populationen und in reinen Linien. Ein Beitrag zur Beleuchtung schwebender Selektionsfrage.* 68 pp.—Jena.

Jollos, V. 1921. Experiementelle Protistenstudien. I. Untersuchungen über Variabilität und Vererbung bei Infusorien—*Arch. Protistenkd.*, Jena, **43** : 1—222.

Kleinschmidt, O. 1900. Arten oder Formenkreise ?—*J. Ornith.*, Leipzig, **48** : 134-139.

Kleinschmidt, O. 1930. *Progress of the Organic World,* (English translation from German original, 192 pp.)—London (Witherby & Witherby).

Lamarck, J. B. 1809. *Philosophie Zoologique.*—Paris. (English translation as *Zoological Philosophy*, by H. Elliot, 1914, xcil + 410 pp. London).

Lamarck, J. B. 1815-1822. *Histoire Naturelle des Animaux sans vertebres.* 7 vols.—Paris.

Linnaeus, C. 1758. *Systema Naturae.*

Lysenko, T. D. 1943. *Heredity aud its Variability.* [In Russian]—Moscow (Commisar. Agric. U. S. S. R.). (English translation by T. Dobzhansky, 6 + 65 pp. 1946. New York (King's Crown Pr.).

Mayr, E. 1942. *Systematics and the Origin of Species from the Viewpoint of a Zoologist* xiv + 334 pp.—New York.

Misra, S.D., Nair, K. R. and Roonwal, M.L. 1952. Studies in intraspecific variation. Part VI. Dynamics of variability of certain characteristics of eye-stripe composition during phase-transformation in the initial years (1949-1950) of a swarming cycle in India, together with a statistical note on Roonwal's Hypotheses on prediction of swarming. *Indian J. Ent.*, New Delhi, **14** (2) : 95-152. (Preliminary note in *Curr. Sci*, Bangalore, **20** (6) : 164-165, 1951.)

Nair, K.R. 1952. A statistical note on Dr. Roonwal's hypotheses for prediction of swarming of the Desert Locust. Pp. 136-146. (In Misra, Nair & Roonwal : Studies in intraspecific variation. Part VI, *vide supra.*). *Indian J. Ent.*, New Delhi, **14** (2) : 95-152.)

Rensch, B. 1929. *Das Prinzip geographicher Rasenkreise und das Problem der Artbildung.* 206 pp.—Berlin (Bronträger).

Rensch, B. 1934. *Kurze Anweisung für zoologische systematische Studien.* pp. 116 Leipzig (Akad. Verlag).

Rensch, B. 1939. Typen der Artbildung.—*Biol. Rev.*, Cambridge, **14** : 180-222.

Rensch. B. 1947. *Neuere Probleme der Abstammungslehre. Die transspezifische Evolution.* vii+407 pp.—Stuttgart (F. Enke).

Robson, G.C. and Richards, O. W. 1936. *The Variations of Animals in Nature.* 425 pp. London.

Roonwal, M.L. 1936. On the existence of two different types of striped eyes among solitary type specimens of the Desert Locust, *Schistocerca gregaria* Forsk.—*Current Sci.*, Bangalore, **5** (1): 24.

Roonwal, M.L. 1940. On the subspecies of the Ring-Dove, *Streptopelia decaocta* (Frivaldszky). *Rec. Indian Mus.*, Calcutta, **42** (3) : 437—752.

Roonwal, M. L. 1941. Catalogue of birds in the Indian Museum. I. Columbae (Pigeons and Doves).—*Rec. Indian Mus.*, Calcutta, **43** (3) : 281—360.

Roonwal, M. L. 1945. New hypotheses for the prediction of the swarming of the Desert Locust.—*Bull. ent. Res.*, London, **35** (4) : 391—393.

Roonwal, M. L. 1946*a*. On a new phase character, the metasternal interspace, in the Desert Locust, *Schistorceca gregaria* (Forskal) (Orthoptera, Acrididae).—*Proc. R. ent. Soc. London (A)*, London, **21** (1—3) : 13—15.

Roonwal, M. L. 1946*b*. Studies in intraspecific variation. I. On the existence of two colour-types in the adults and hoppers of the *solitaria* phase in the Desert Locust, *Schistocerca gregaria* (Forskal) (Orthoptera, Acrididae).—*Rec. Indian Mus.*, Benaras [Calcutta], **44** (4): 369-374. (Preliminary note in *Nature*, London, **155**, 1945, p. 792.)

Roonwal, M. L. 1946*c*. Studies in intraspecific variation. II. New Rules governing the correlation between normal and extra-moulting and the directional reversal of the elytron-wing complex in the Desert Locust and other Acrididae (Orthoptera).—*Indian J. Ent.*, New Delhi, **7** (1 & 2) [1945] : 77—84.

Roonwal, M. L. 1947*a*. Variation and structure of the eyes in the Desert Locust, *Schistocerca gregaria* (Forskal).—*Proc. R. Soc. Lond.* (B), London, **134** : 245—272, 3 pls.

Roonwal, M. L. 1947*b*. Evolutionary significance of periodicity of variation-intensity and population-flux in the Desert Locust.—*Nature*, London, **159** : 872—873.

Roonwal M. L. 1949*a*. Modern trends in systematics. (Presidential Address to the Section of Zoology and Entomology, Indian Science Congress, (1949).—*Proc. 36th Indian Sci. Congress* (Allahabad, 1949), Pt. 2, *Presidential Addresses*, Calcutta, pp. 111-138.

ROONWAL, M. L. 1949*b*. On zoological standards and progress. Annual Address delivered before the Zoological Society of India at Patna on 1st January 1948.—*J. zool. Soc. India,* Calcutta, **1** (1) : 8-16.

ROONWAL, M. L. 1949*c*. Studies in intraspecific variation. III. Body-size and biometrical ratios in variation types of individuals of the Desert Locust, *Schistocerca gregaria.* (Forskal) (Orthoptera, Acrididae).—*Rec. Indian Mus.,* Calcutta, **45** (2-3) [1947] : 149-165.

ROONWAL, M. L. 1949*d*. Studies in intraspecific variation. IV. The role of some variations, *e. g.,* eye-stripes, etc., as 'population indicators' in the Desert Locust, and their practical importance.—*Rec. Indian Mus.,* Calcutta, **45** (2-3) [1947] : 167-180.

ROONWAL, M. L. 1949*e*. Similarity between the Collared Scops Owls of Malay and peninsular India.—*Proc. nation. Inst. Sci. India,* Calcutta, **15** (8) : 395.

ROONWAL, M. L. 1949*f*. Systematics, ecology and bionomics of mammals studied in connection with tsutsugamushi disease (scrub typhus) in the Assam-Burma War Theatre during 1945.—*Trans. nation. Inst. Sci. India,* Calcutta **3** (2) : 67-122, 6 pls., 15 tables.

ROONWAL, M. L. 1950. Contributions to the fauna of Manipur State, Assam. Part III. Mammals, with special reference to the family Muridae (Order Rodentia).—*Rec. Indian Mus.,* Calcutta, **47** (1) : 1-64, 9 pls.

ROONWAL, M. L. 1952. Section I. General introduction. (*In* Misra, S. D., Nair, K. R. and Roonwal, M. L. : Studies in intraspecific variation. Part VI.)—*Indian J. Ent.,* New Delhi, **14** (2) : 96—100 (*vide supra*).

ROONWAL, M. L. 1954 *a*. A brief review of the progress of entomology in India during the period 1938-1950, together with a bibliography.—*Mem. ent. Soc. India,* New Delhi, **3** : 1-119.

ROONWAL, M. L. 1954*b*. On a new evolutionary phenomenon: The sharp increase of intraspecific variation in minimum populations, as evidenced by the Desert Locust.—*Rec. Indian Mus.,* Calcutta **51** (4) [1953], 4 pls. (1 col.). (*In press*). (Preliminary account in *Bull) nation. Inst. Sci. India,* Calcutta, 1954. (*In press*). Abstract in "Symposium on Organic Evolution (March, 1953). Programme and Abstracts of Papers (*National Inst. Sci. India*), New Delhi, pp. 10—11.

ROONWAL, M. L. and MISRA. S. D. 1952. Section 3. Variability in a sample of Desert Locust population taken from a swarm in the Rajputana Desert, India, in 1950, the second year of a swarming cycle, together with a discussion on the dynamics of phase-transformation. (*In* Misra, S. D., Nair, K. R. and Roonwal, M. L. : Studies in intraspecific variation. Part VI.)—*Indian J. Ent.,* New Delhi, **14** (2) : 112-126. (*vide supra*).

ROONWAL, M. L. and NATH, B. 1949*a*. Contributions to the fauna of Mainpur State, Assam. Part II. Birds.—*Rec. Indian Mus.,* Calcatta **46** (1-4) [1948] : 127-182, 1 pl.

ROONWAL, M. L. and NATH, B. 1949 *b*. Discontinuous distribution of certain Indo-Malayan mammals, and its zoogeographical significance.—*Proc. nation. Inst. Sci. India,* Calcutta, **15** (8) : 375-377.

THORPE, W. H. 1930. Biological races in insects and allied groups.—*Biol. Rev.,* Cambridge, **5** : 177-212.

TURESSON, G. 1922. The species and the variety as ecological units.—*Hereditas,* Lund, **3** : 100-113.

TURESSON, G. 1925. The plant species in relation to habit and climate.—*Hereditas,* Lund, **6** : 147-236.

TURESSON, G. 1931. The geographical distribution of the Alpine ecotype of some Eurasiatic plants.—*Hereditas,* Lund, **15** : 329-346.

UVAROV, B. P. 1921. A revision of the genus *Locusta,* L. (*Pachytylus,* Fieb.), with a new theory as to the periodicity of migrations of locusts. *Bull. ent. Res.* London, **12**: 135-163.

UVAROV, B. P. 1928. *Locusts and Grasshoppers. A Handbook for Their Study and Control.* 352 pp.—London (Imp. Inst. Entom.).

LIST OF PUBLICATIONS SO FAR RECEIVED IN EXCHANGE OF THE AGRA UNIVERSITY JOURNAL OF RESEARCH

ARGENTINA

Publications of Faculty of Agronomy, University of Buenos Aires.

AUSTRALIA

Memoirs of the Queensland Museum.
Proceedings of the Royal Society of Queensland.
Books Published in Australia.
Catalogue of 16 mm films.
Australian Journal of Agricultural Research.
Australian Journal of Zoology.
Australian Journal of Marine and Fresh-Water Research.
Proceedings of the Linnean Society of New South Wales.

AUSTRIA

Annalen des Naturhistorischen Museum.
Die pyramide.
Der Ewrige Enid.
Liturgie und Kirchen-Kunet.
Sitzungsberichte, Akademie der Wissenschaften.
Verhandlungen der zoologisch-botanische Gesellschaft zu Wien.

BELGIUM

Bulletin du Jardin Botanique de l'Etat.
Bulletin and Annales Societe Entomologique.
Memoires de la Societe Entomologique.
La Bibliographie de Belgique.

BRAZIL

Documentos Historicos Biblioteca Nacional Rio de Janeiro.
Indice Bibliografico das Publicacoes.
Bibliografia Bibliotecologica Brasileira.

BULGARIA

Annuaire de l' Univ. de Sofia.
La Bulgarie D' Aujourd Hui.
Comptes Rendus de l' Academie Bulgare des Sciences.

CANADA

Revue Canadienne de Biologie.
University of Ottawa, Faculty of Science Calendar.
Programme of Studies, University of Ottawa.

CEYLON

University of Ceylon Review.

CHINA

Acta Scientia Sinica

CZECHOSLOVAKIA

Publications of Faculty of Science, Czechoslovakia.
Publications of Veterinary High School.
Acta Societatis Entomologicae Cecholoveniae.
Bulletin International Ceska Akademie Ved.
Acta Musei Nationalis Pragae.
Vestnik Czekoslov. Akademie Ved.
Journal of the Czechoslovak Oriental Institute.
Collection of Czechoslovok Chemical Communications.
World Students News.

DENMARK

Acta Arctica.
Acta Philologica Scandininavica.
Det Kungelige Danske Viden. Sel. Dan Biol. Medd.
Acta Historica Scientiarum Naturalium et Medicinalium.

DOMINICAN REPUBLIC

Annales Universitate de Santo Domingo.
Exposition del Libro, Mexicano, Univ. de Santo Domingo.

EGYPT

A study of hairs and wools, Egypt University.
Fac. Medicine.
Lectures in the history of medicine, Egypt University.
Bulletin of the Faculty of Science, Egypt University.

EIRE

The Scientific Proceedings of the Royal Dublin Society.

FINLAND

Heinz Reinhold : Humoristische.
Sitzungsberichte Soumalainen. Tiedeakatema, Helsinki.

FRANCE

Comptes Rendus de l' Académie des Sciences Paris.
Archives de Zoologie experimentale et generale.
Annales de l' Institute, Fourier.
Annales de l' Universitate de Lyone.
Publications de l' Institut de Statistique Univ. de Paris.

GERMANY

Sitzungsbterichte der physikalisch-medizinschen Sozietät zu Erlangen.
Mitteilungen aus dem zoologischen Museum.
Beiträge zur Entomologie.
Notizblatt.
Wissenschaftliche Zeitschrift der Humboldt Universität zu Berlin.
Decheniana.
Nachrichten der Akademie der Wissenchaften.
Kühn-Archiv.
Studienfürer.
Medizinische Klinik.
Sitzungsberichte der Akademie mathem. naturw. Klasse.
Mathemaik Naturwissenschaften.
Gesellschaft und Sprache.
Wissenschaft. Zeitchrift der Univ. Rostock (als Manuscript Gedruckt).

GREAT BRITAIN.

Summaries of Theses approved for higher degrees in the Faculty of Science Glasgow University.
Annual Reports of the Progress of Chemistry, Chemical Society, London.
Quarterly Reviews, Chemical Society, London.
Proceedings of the Cambridge Philosophical Society.
A Hand book and history of 60 years progress, Edinburgh Public Library.
The National Library of Wales Journal.
Hand list of Manuscripts in the National Library of Wales.
Rothamsted Experimental Station Annual Report.
List of accessions to the library, Science Museum Library.
Endeavour, London.
Review of Applied Entomology.
A description of the work of the department of Science and Industrial Research, London.

Government publications sectional list.
Chemistry Research, Deptt. of Sci. and Industrial Research.
Forest Products Research, Department of Sci. and Ind. Res.
Pest infestation Research, Deptt. of Sci. and Industrial Res.
Department of Scientific and Industrial Research Report.
Colonial plant and animal products.
The Journal of the Linnean Society of London.

HAWAII

Proceedings of the Hawaiian Entomological Society.

HUNGARY

Annales Hist. Nat. Mus. Nationalis Hungarici.
Acta Chemica, Magyar Tudo. Akad. Budapest.

ISLAND

Arbox Haskola Islands.

INDIA

Central Rice Research Institute Annual Report.
Bulletin of the Botanical Society, University of Saugar,
Education and Psychology, Bikaner.
Reprints of the Research Papers, Raman Institute,
Journal of the Indian Institute of Science.
Report of the Haffkine Institute.
Reprints of the published papers, Heffikine Institute, parel, Bombay.
Journal of the Asiatic Society, Calcutta.
The 45th annual report of the Central Committee, Parel, Bombay.
The Pasteur Institute of South India, Annual Report of the Director.
The Pasteur Institute of South India Scientific Report.
Indian Council of Medical Research, the Nutrition Research Laboratory annual report.
Indian Research fund association, a history of its origin and development.
Indian Forest Records.
Bibliography of Scientific Publications, Unesco.
Scientific Reports of the Indian Agricultural Research Institute, New-Delhi.
Journal of the Scientific and Industrial Research, New-Delhi.
Report of the second reviewing committee of C.S.I.R.
Proceedings of the National Institute of Sciences of India.
Journal of the Clinical Society, G. R. Medical College, Gwalior.
G.R. Medical College, Magazine.

Journal of the Madras University.
Journal of the Indian Society of Soil Science.
The Journal of the M.S. University of Baroda.
The Journal of the Tanjore Saraswati Mahal Library.
Journal of the Gauhati University.
University of Rajputana Studies Physical Sciences.
Journal of the Visva-Bharti, Santiniketan.
Andhra University Colleges Magazine and Chronicle.
University of Allahabad Studies.
Research Bulletin of rhe East Punjab University.
Reprints of the published papers, Indian Agri. Res. Inst. Coimbatore.
Half Yearly Journal of the Mysore University.
Marathi Sanshodhan Patrika.
Journal of the Saugar University.
Scientific Journal of Banaras Hindu University.
Journal of the Bombay University.
Annual Report of the Chemical Examiner, Agra.

REPUBLIC OF INDONESIA

Universitit Negeri Gadjah Mada Jogjakarta Berita Ilmu Pengetahuan Populer.

IRAN

Universite de Teheran Review.

ISRAEL

Bulletin of the Research Council of Israel.

ITALY

Bollettino del' Instituto di Entomologia.
Bollettino del Musei Instituti Biologici
Doriana Annali Museo Civico do Storia Naturale, Genova.
Annali Museo Civico di Storia Naturale.
Reprints of the Published papers from Genova.
Rendiconti del seminario Matematico.
Review of Economic condition in Italy.

JAPAN

The Journal of the Faculty of Agriculture, University of Fukuoka.
Memoirs of the College of Science, University of Kyoto.
Bulletin of the National Science, University of Kyoto.

Japanese Journal of Medical Science and Biology.
Osaka University Law Review.
Osaka Economics papers, Osaka University.

JUTLAND.

Acta Jutlandica

HOLLAND

Mededelinge Konig. Nederland Akademie, Amsterdam.
Neywe Recks „ „ „ „
Intergentlal Reeht Algerije.
Zoologische Verhandelingen.
Zoologische Mededelingen.

NEW ZEALAND

Records of the Auckland Institute and Museum.
Zoology publications of Victoria College.
Dominion Museum Records in Entomology.
Records of the Dominion Museum.

NORWAY.

Nytt Magasin for Bottanik, Osto
Med. Zool. Museum, Oslo
Forhandlinger, Trondheim:
Skrifter, Trondheim.
Museet Arbok, Trondheim.

PAKISTAN

The Scientist, Pakistan.

PHILIPPINES

The Philippine Agriculturist.
Philippines Social Sciences and humanities Review.

POLAND

Bulletin International Polska Akad. Cracow.
Folio Morphologica, Warsaw.
Acta Sociatatis Botanicorum Polniae.

PORTUGAL

Revista da Faculdade de Ciencias Unversidade de Lisboa.

SOUTH AFRICA

Journal of the Society of the University of Natal.

SPAIN

Memoria de Los Patronatos.
Memoria de La Univ. de Madrid.
Discurso.

SWEDEN

Zoologiska Bidrag fran. Uppsala.
Annals of the Royal Agricultural College of Sweden.
Proceedings of the Royal Physiographic Society, Lund.
Acta Universitatis Nova series.
The Mechanisms of gas transport in the euphysoclist swimbladder, I und
Duty and Utility, a study in English moral Philosophy,
Chiefs and gods, By Mr. Pettersson,
Kungl. Sevenska Vetenskap. Handlinger.
Arkiv far Matematik.
Acta Physiologica Scandinavica.

SWITZERLAND

Dos Schweizer Buch. Le Livre Suisseil Libro Svizzero.
Actes de la soc. Helv. Sciences Naturelles, Berne.
Bulletin de la Societe Vaudoise des Sciences Naturelles.
Bulletin der Schweiz. Akademie der medizinischen Wissenshaften.

U. S. A.

Iowa State College Journal of Science.
University of California publications in Zoology and Entomology.
University of California Insect Survey Bulletin.
University of Colorado Studies series in Biology, Chemistry and Pharmacy.
University of Colorado Bulletin.
Complete Catalogue Harvard College Library.
Papers of the Michigan Academy of Science, Art and Letters.
Report on Venuzuala Rice Experimental Programme, Rockfeller Foundation.
Natural History Miscellanea.
Bulletin of the Chicago Academy of Sciences.
Museum activities, Chicago Academy
Annual report of the State Board of Agriculture, Michigan State College.
The Quarterly Bulletin, Michigan State College.

Lewin's Toqological and Vector Psychology, By R.W. Beeper, University of Oregon.
The Individual in simpler from, University of Oregon.
La fortune du Tasse en France, ,, ,, ,,
Metaphor in the Nondramatic works of Jean Giraudoux.
Professor Longfellow of Harvard.
The Epistolary Novel in the late 18th century.
Three studies in Philology.
Transportation and Politics.
The tax systems of Australasia.
Arkansas Academy of Science Proceedings.
Quarterly Journal of the Florida Academy of Sciences,
University of Iowa Doctoral dissertations abstracts and references
University of Lowa studies in Engineering.
nts of the published papers, Cornell University.
nell University Studies.
nual Report of Bucknell students for foreign students,
ne beginnings of the Bucknell University.
Academy of Science Transaction, Kansas State College.
Abstracts of doctoral dissertations, University of Nebersaka.
Proceedings of the Lauisiana Academy of Sciences.
Minnesota Academy of Sciences Proceedings.
American Journal of Science, Yale University.
American Museum Novitates.
Proceedings of the Academy of Natural Sciences of Philadelphia.
Nasulae Naturae, Academy of Natural Sciences of Philadelphia.
Reprints of the published papers, Princeton University.
Illinois Biological Monographs.
Illinois studies in Language, Literature.
Acanthocephala of North American Mammals.
Information Bulletin, Library of Congress.
Quarterly Journal of current acquisitions, Library of Congress.
Challenge in Eastern Europe.

VENEZUELA

Bulletin Informativo, Univ. Central Venezuela, caracas.
Anales dela Univ. Central De Venezuela.
Cultura Universitaria Univ. Central de Venezuela.

YUGOSLAVIA.

Nova Proizvodnja.

19. Studies on the manuring of wheat. II.—Effect of excessive Nitrogenous mauring on wheat. By Ranvir Singh and N. K. Anant Rao ... 499
20. Study of Myocardial Damage by Injection. By K. S. Mathur and P. N. Wahi 509
21. Liver function studies in Viral Hepatitis. By P. N. Wahi and M. M. Arora 519
22. Sexual Dimorphism and Eversion of the hemipenes in *Uromastix hardwickii* Gray. By Jagdish Chandra Agarwal 535
23. The Anatomy of the Hemipenes in *Uromastix hardwickii* Gray. By Trilok Majupuria 539
24. On the lower Systematic Categaries and their significance in Taxonomy and evolution. By M. L. Roonwal 545
25. List of Publications so far Received in Exchange of the Agra University Journal of Research. 579

Edited by Dr. M. S. Mani, printed by Mr. H. K. Kapur at the Agra University Press, and published by Dr. L. P. Mathur, Senate House, Agra University, Agra.

CONTENTS

PAG

1. Floral Morphology and Embryology of *Hedera nepalensis* K. Koch. By DALBIR SINGH 289
2. Studies in the family Loranthaceae. By BAHADUR SINGH ... 30
3. Effect of certain synthetic growth regulators on the form of leaf of *Brassica campestris* Linn. and *Lens esculenta* Moench. By V. N. KRISHNA PILLAI and S. C. CHAKRAVARTI 31
4. Morphological Studies in *Morus* Spp. By SATYA PAL SINGH ... 32
5. Gametogenesis and fertilization of *Stephegyne parviflora* Korth. By S. S. RAMAM 34
6. Floral Anatomy of *Heliotropium indicum* L. By RAMJI SHARMA ... 349
7. Effect of mixed cropping on the incidence of Root-rot, wilt and associated diseases of *Cyamopsis psoralioides*. By R. S. SINGH ... 359
8. Root-rot and Wilt of *Cyamopsis psoralioides* in relation to date of sowing. By R. S. SINGH 375
9. Entomological Survey of the Himalayas. II.—On a Collection of Odonata. By SANTOKH SINGH and H. N. BAIJAL 385
10. Contributions to our Knowledge of Fig insects (Chalcidoidea: Parasitic Hymenoptera) from India. VI.—On six species of Agaoninae. By K. J. Joseph 401
11. Descriptions of five new and Records and Redescriptions of two known Bethyloidea (Parasitic Hymenoptera) from India. By CHANDY KURIAN 417
12. Early Embryonic development of *Mylabris pustulata* Thunb. Part II.—Changes leading to the formation of the germ band. By S. R. DEOBHAKTA 441
13. Entomological Survey of the Himalayas. Part III.—On a collection of Dermaptera. By H. N. BAIJAL and SANTOKH SINGH ... 455
14. The Bionomics of the *Mimusops* Gall Thrips *Arrhenothrips ramakrishinae* Hood. By T. N. ANANTHAKRISHNAN 463
15. Growth of Boundary Layer over an Infinite Plate in a compressible Fluid—Non-Adiabatic Flow. By M. RAY 475
16. Condensation of Malon-1. 3. 4. Xylidic Acid with Aromatic Aldehydes Part. III.—With halogen and nitro substituted salicylaldehydes. By SANT PRAKASH and P. I. ITTYERAH 481
17. Condensation of Aromatic Aldehydes with Malon-1. 3. 4-Xylydic Acid. By S. GHATAK, JWALA PARSAD and P. I. ITTYERAH ... 489
18. Analysis of Inorganic Compounds by paper chromatography. Part III.—Study of various factors effecting the RF values of cations in the separation of a mixture of copper, lead, bismuth, cadmium and mercury. By SWARUP NARAIN TEWARI 493

(Contd. inside cover).